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(54) **SYSTEM AND METHOD FOR PROTECTING A WORKSPACE FROM AIRBORNE CONTAMINANTS**

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(Continued)

(58) **Field of Classification Search**
CPC A61L 9/20
See application file for complete search history.

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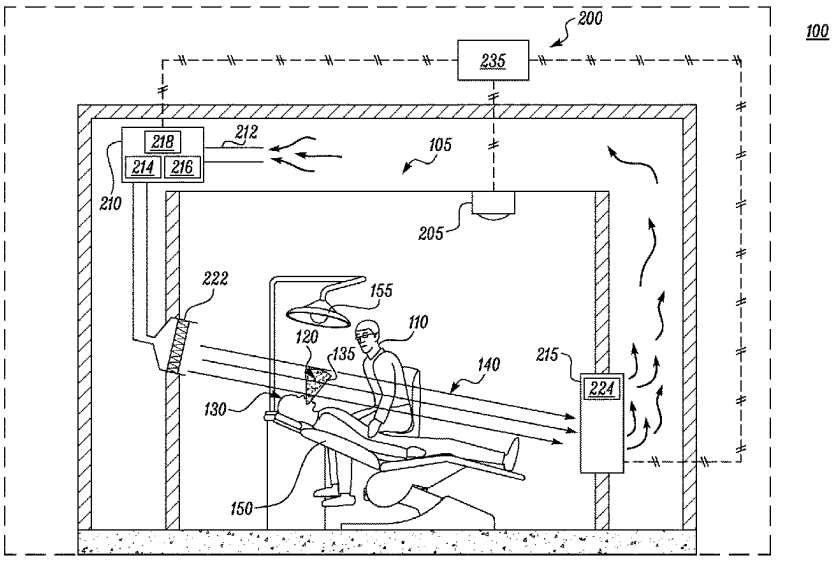
(57) **ABSTRACT**

A system for protecting a workspace from airborne contaminants comprises at least one sensing capturing unit, an air transmission unit, an air capturing unit, and a processor. The processor is configured to receive a sensing data associated with the workspace from the at least one sensing capturing unit and determine presence of at least one source of transmission of the airborne contaminants. The processor is further configured to configure a capture zone within the workspace based on the determined at least one source of transmission of the airborne contaminants. The processor is configured to control the air transmission unit to direct a unidirectional flow of air over the configured capture zone, thereby directing movement of the airborne contaminants in the capture zone and further to control the air capturing unit to capture the unidirectional flow of air, along with the airborne contaminants, directed from the air transmission unit.

9 Claims, 6 Drawing Sheets



(51) **Int. Cl.**

B01D 46/00	(2022.01)
B01D 46/44	(2006.01)
B01D 46/46	(2006.01)
F24F 8/10	(2021.01)
F24F 11/79	(2018.01)
F24F 110/64	(2018.01)

(52) **U.S. Cl.**

CPC ***B01D 46/0086*** (2013.01); ***B01D 46/448*** (2013.01); ***B01D 46/46*** (2013.01); ***F24F 8/10*** (2021.01); ***F24F 11/79*** (2018.01); *A61L 2209/111* (2013.01); *A61L 2209/14* (2013.01); *B01D 2279/50* (2013.01); *F24F 2110/64* (2018.01)

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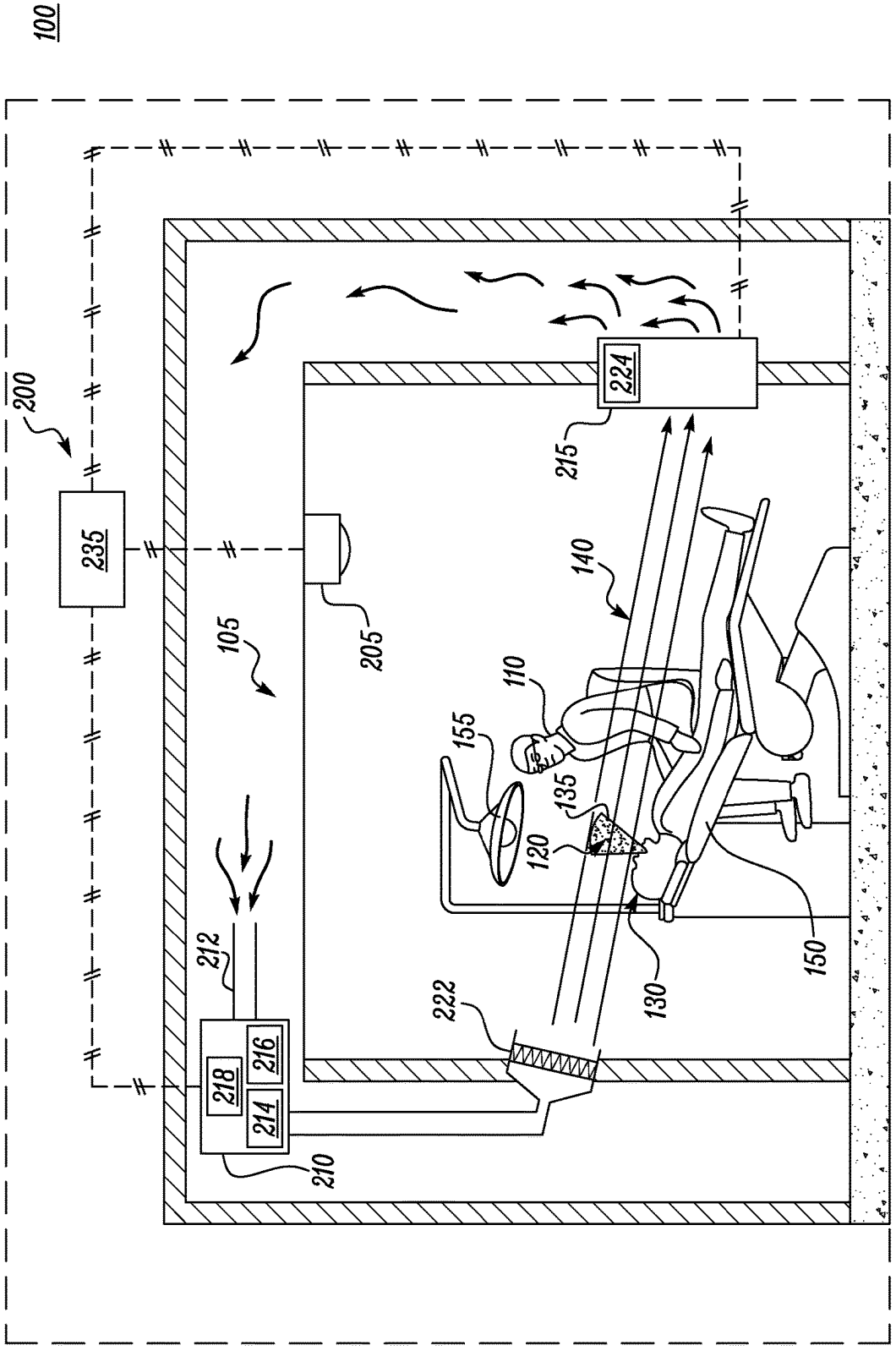
100
200
235
105
205
224
215
140
110
155
135
120
150
130
222
212
218
216
214
210

FIG. 1

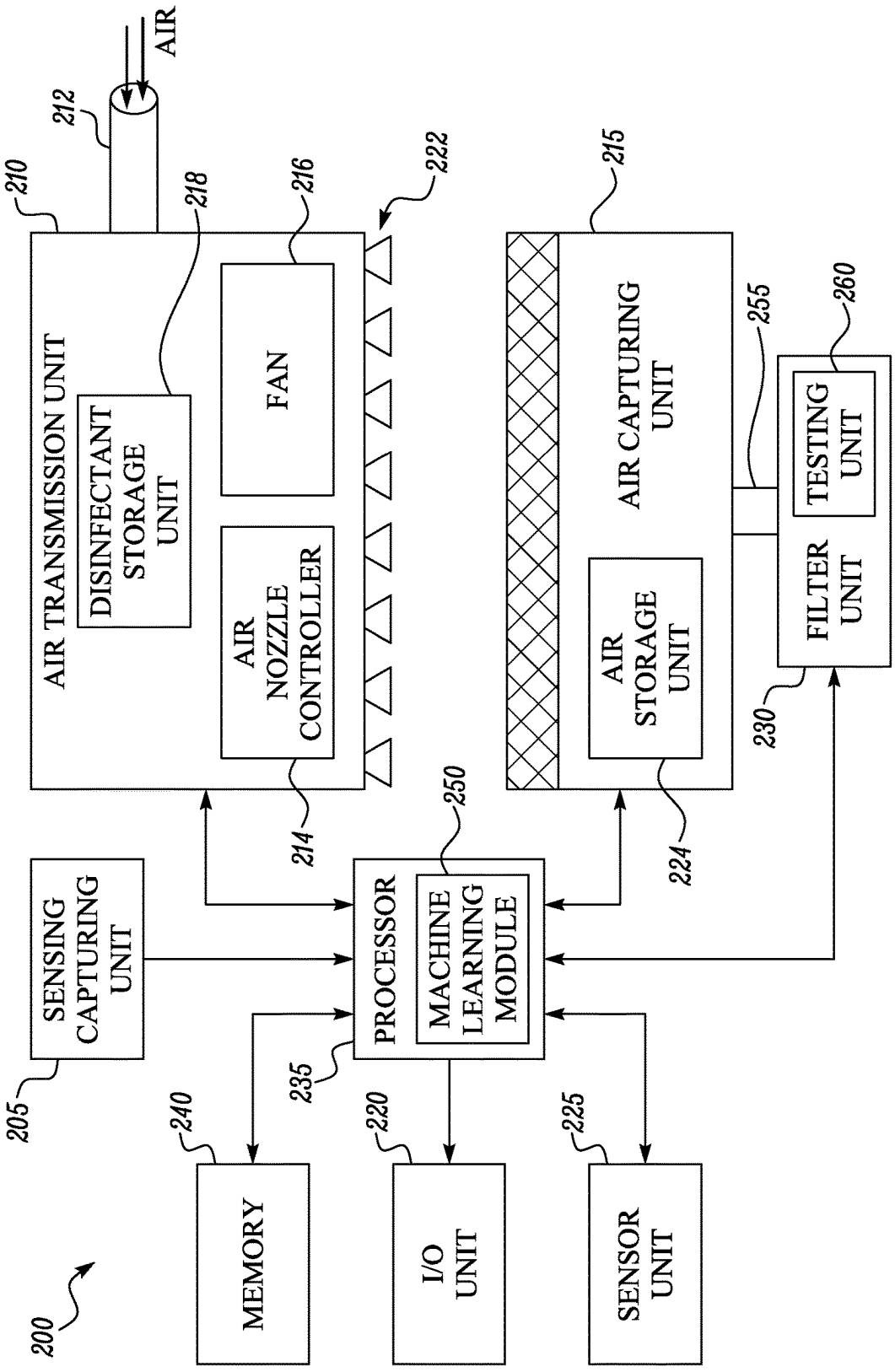
AIR
212
210
218
216
222
215
AIR TRANSMISSION UNIT
DISINFECTANT STORAGE UNIT
FAN
AIR NOZZLE CONTROLLER
AIR CAPTURING UNIT
255
260
TESTING UNIT
FILTER UNIT
AIR STORAGE UNIT
230
214
224
250
SENSING CAPTURING UNIT
PROCESSOR
MACHINE LEARNING MODULE
205
235
240
220
225
MEMORY
I/O UNIT
SENSOR UNIT
200

FIG. 2

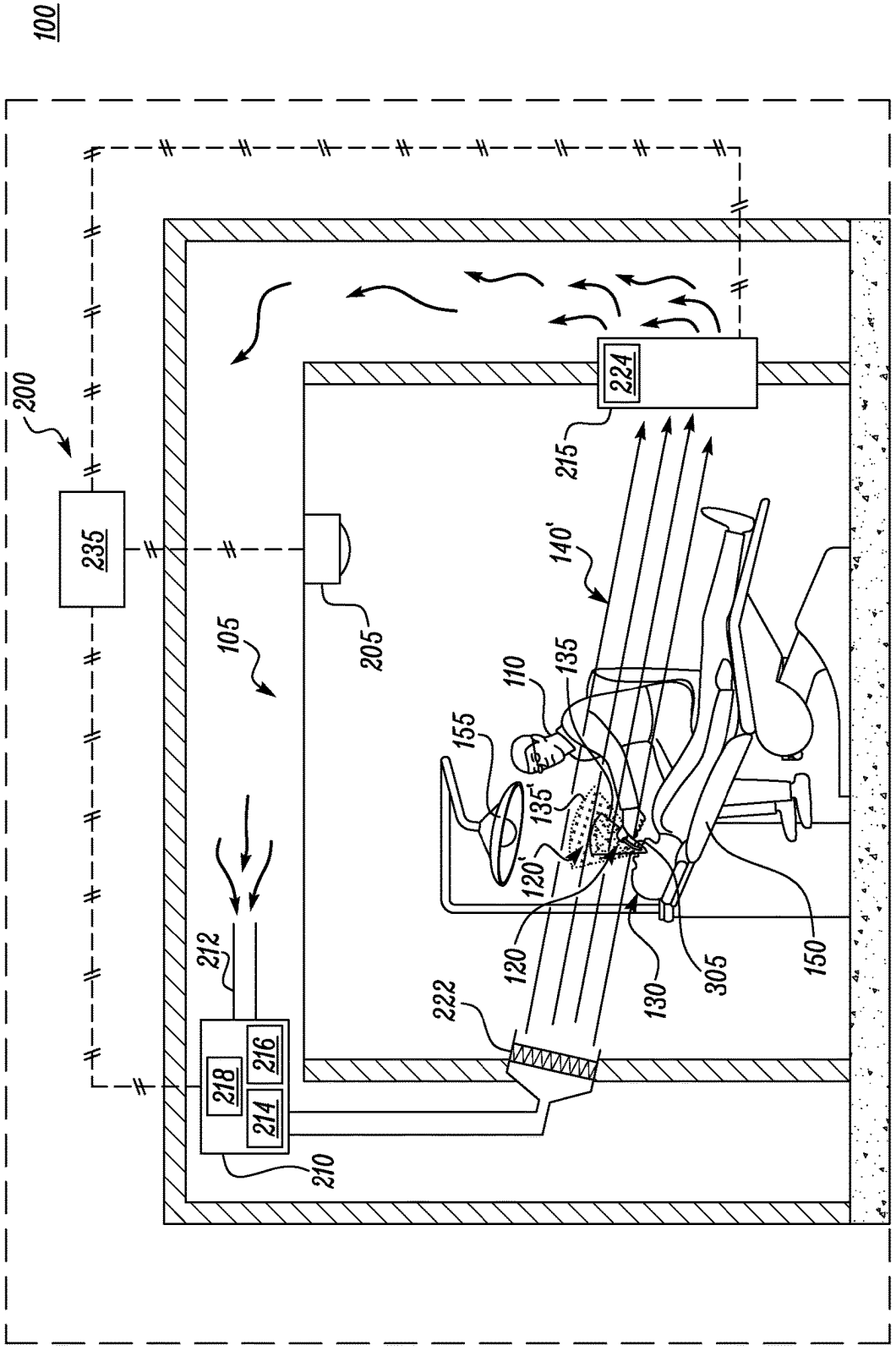
100
200
235
105
205
224
215
140'
135
110
155
135'
120'
120
130
305
150
222
212
218
216
214
210

FIG. 3

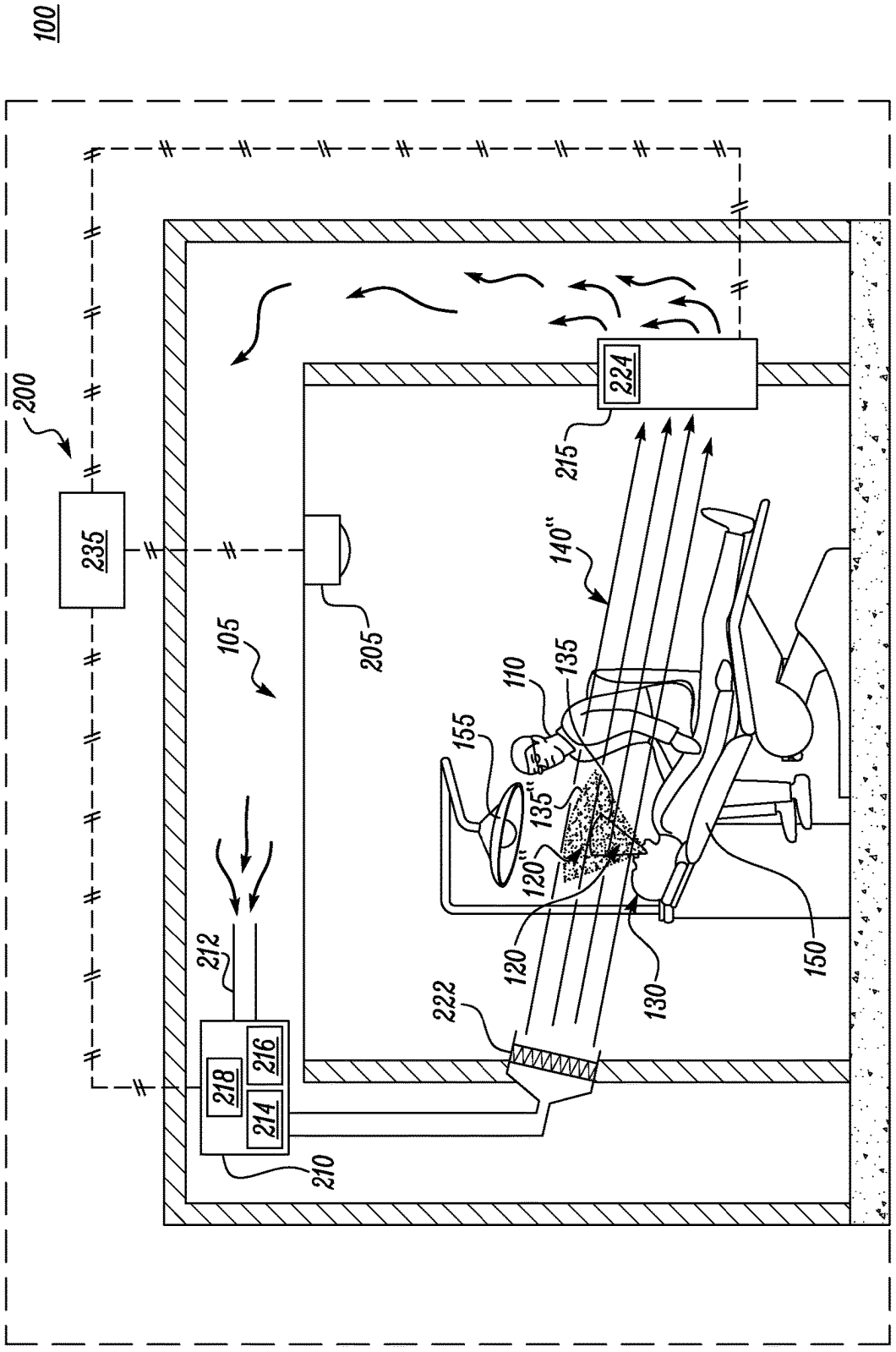
100
200
235
105
205
224
215
140"
110
135
155
135"
120"
120
130
150
222
212
218
216
214
210

FIG. 4

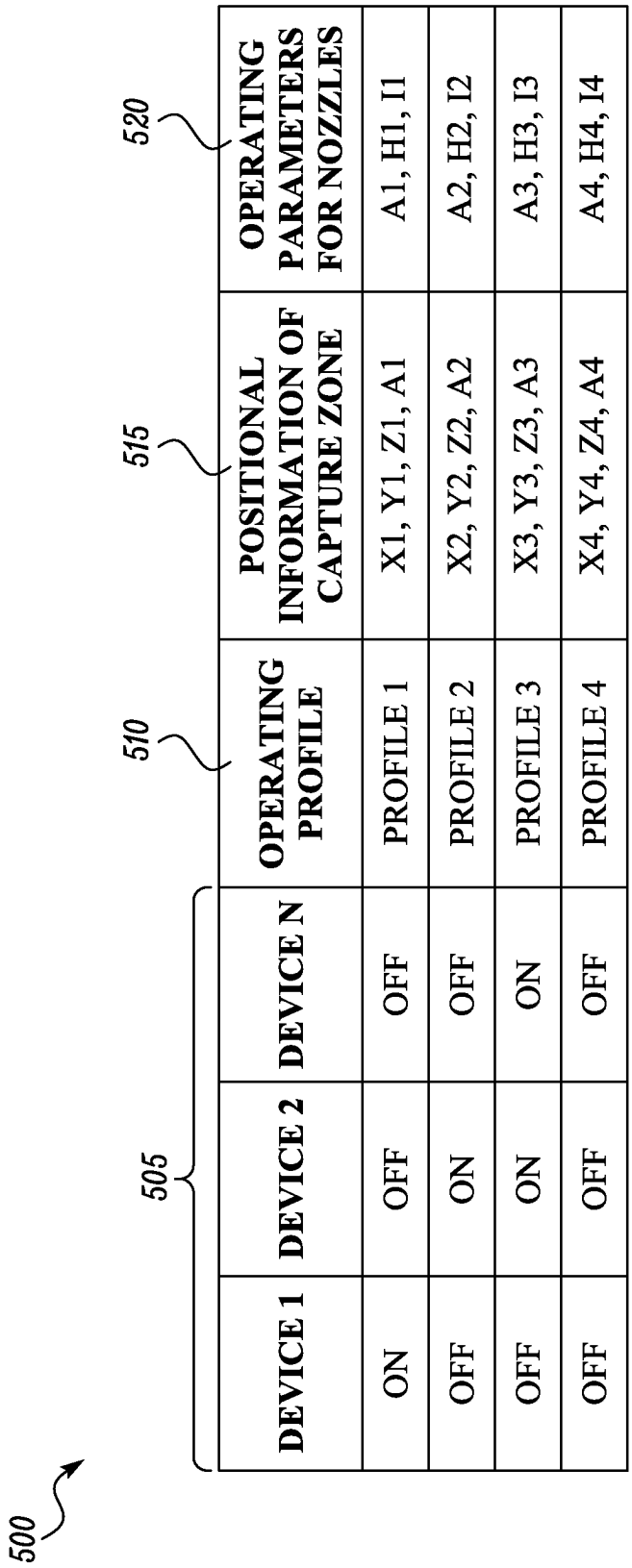
500
505
510
515
520
DEVICE 1
DEVICE 2
DEVICE N
OPERATING PROFILE
POSITIONAL INFORMATION OF CAPTURE ZONE
OPERATING PARAMETERS FOR NOZZLES
ON
OFF
OFF
PROFILE 1
X1, Y1, Z1, A1
A1, H1, I1
OFF
ON
OFF
PROFILE 2
X2, Y2, Z2, A2
A2, H2, I2
OFF
ON
ON
PROFILE 3
X3, Y3, Z3, A3
A3, H3, I3
OFF
OFF
OFF
PROFILE 4
X4, Y4, Z4, A4
A4, H4, I4

FIG. 5

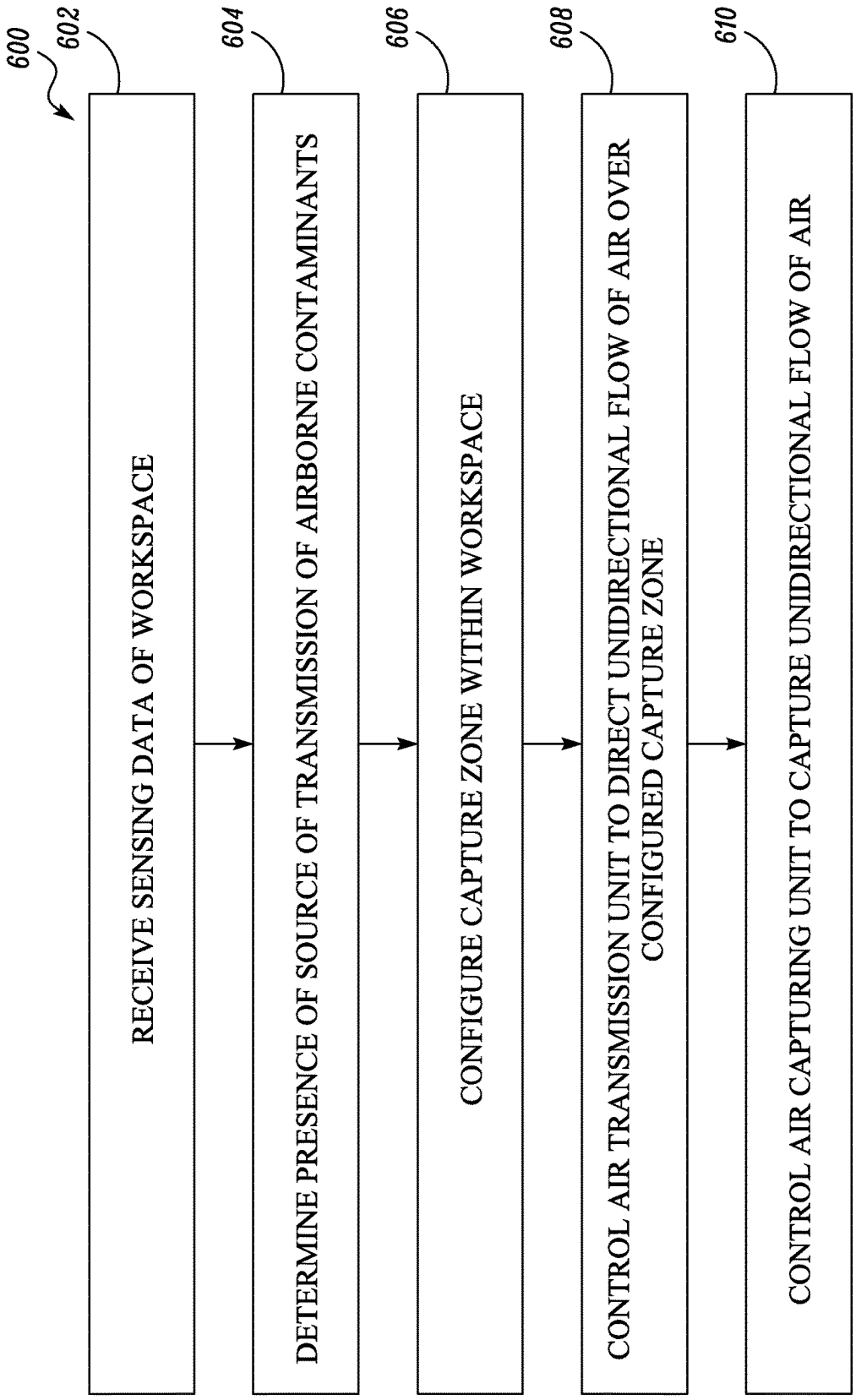
600
602
RECEIVE SENSING DATA OF WORKSPACE
604
DETERMINE PRESENCE OF SOURCE OF TRANSMISSION OF AIRBORNE CONTAMINANTS
606
CONFIGURE CAPTURE ZONE WITHIN WORKSPACE
608
CONTROL AIR TRANSMISSION UNIT TO DIRECT UNIDIRECTIONAL FLOW OF AIR OVER CONFIGURED CAPTURE ZONE
610
CONTROL AIR CAPTURING UNIT TO CAPTURE UNIDIRECTIONAL FLOW OF AIR

FIG. 6

SYSTEM AND METHOD FOR PROTECTING A WORKSPACE FROM AIRBORNE CONTAMINANTS

BACKGROUND OF THE INVENTION

Although medical and healthcare professionals place a high priority on the health and safety of both patients and staff, the close proximity of the patient to the healthcare professionals performing services creates an environment conducive to the spread of infection. The presence of a variety of infectious airborne contaminants transmitted by the patients has become even more concerning with the pandemic conditions of the Coronavirus Disease 2019 (COVID-19). Public health officials recommend (and in some places mandate) that the mouth and nose should be covered with a cloth (or other material) face cover. As such, a common preventive measure includes the wearing of personal protective equipment (PPE) such as masks, face shields, gloves and the like, to protect from such infectious airborne contaminants. However, since PPE were originally designed with the intention of blocking blood-borne, liquid-or-solid particles, and not airborne contaminants, they do little to mitigate these risks. This is further evident by the formal references and standards for infection control, such as in the "Universal Precautions" for the medical industry, whereby nearly all such precautions related to use of PPE are geared to address blood-borne infection risks without any mention of infections caused from the airborne contaminants.

A few PPE options, such as HazMat (hazardous materials) suits, are available that safeguard its users from all contaminants including the airborne contaminants. However, such PPE options are extremely prohibitive in terms of their actual operating use, thereby rendering them irrelevant for day-to-day use, or their utility under delicate and complicated operations where maximal Degree-of-Freedom (DoF) for movement is of paramount importance.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate embodiments of concepts that include the claimed invention and explain various principles and advantages of those embodiments.

FIG. **1** illustrates a workspace environment employing an exemplary system for protecting a workspace from airborne contaminants, in accordance with some embodiments.

FIG. **2** illustrates a schematic block diagram of the exemplary system for protecting the workspace from the airborne contaminants, in accordance with some embodiments.

FIGS. **3** and **4** illustrate the exemplary system employed within the workspace environment, in accordance with some additional embodiments.

FIG. **5** illustrates data stored in the exemplary system for protecting the workspace from the airborne contaminants, in accordance with some embodiments.

FIG. **6** illustrates an exemplary method for protecting the workspace from the airborne contaminants, in accordance with some embodiments.

Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION OF THE INVENTION

In one aspect, a system for protecting a workspace from airborne contaminants comprises at least one sensing capturing unit positioned within the workspace and adapted to capture a sensing data associated with the workspace, an air transmission unit adapted to direct a unidirectional flow of air, an air capturing unit adapted to receive the unidirectional flow of air directed from the air transmission unit, and a processor operatively coupled to the at least one sensing capturing unit, the air transmission unit, and the air capturing unit. The processor is configured to receive the sensing data associated with the workspace from the at least one sensing capturing unit and determine presence of at least one source of transmission of the airborne contaminants in the workspace based on the received sensing data. The processor is further configured to configure a capture zone within the workspace based on the determined at least one source of transmission of the airborne contaminants. The capture zone being an area suspected to be infected with the airborne contaminants transmitted from the determined at least one source of transmission of the airborne contaminants in the workspace. The processor is configured to control the air transmission unit to direct the unidirectional flow of air over the configured capture zone, thereby directing movement of the airborne contaminants in the capture zone and further to control the air capturing unit to capture the unidirectional flow of air, along with the airborne contaminants, directed from the air transmission unit.

In another aspect, a method for protecting a workspace from airborne contaminants comprises receiving, by a processor, a sensing data associated with the workspace captured by at least one sensing capturing unit positioned in the workspace and further determining, by the processor, presence of at least one source of transmission of the airborne contaminants in the workspace based on the received sensing data. The method further comprises configuring, by the processor, a capture zone within the workspace based on the determined at least one source of transmission of the airborne contaminants. The capture zone being an area suspected to be infected with the airborne contaminants transmitted from the determined at least one source of transmission of the airborne contaminants in the workspace. Additionally, the method comprises controlling, by the processor, an air transmission unit to direct a unidirectional flow of air over the configured capture zone, thereby directing movement of the airborne contaminants in the capture zone. The method also comprises controlling, by the processor, an air capturing unit to capture the unidirectional flow of air, along with the airborne contaminants, directed from the air transmission unit.

FIG. **1** illustrates a workspace environment **100** employing an exemplary system **200** for protecting a workspace **105** from airborne contaminants **120**, in accordance with various

embodiments. FIG. **2** illustrates a schematic block diagram of the exemplary system **200**, in accordance with the various embodiments. The workspace environment **100** may be any physical environment that may require protection from airborne contaminants, such as a healthcare facility, a food packaging and processing facility, public transportation, (for example a train, bus, or subway), a shopping mall, a beauty or therapeutic services facility, or the like. The workspace **105** may be a closed space within the workspace environment **100**, such as a dental or medical care facility, or any other type of closed physical space including, but not limited to, a packaging unit and/or a processing unit within the food packaging and processing facility, a retail store within the shopping mall, an office space, and a passenger compartment of the public transportation, and the like. In some embodiments, the workspace environment **100** as well as the workspace **105** may be implemented combinedly as a single space where the system **200** may be implemented. In other embodiments, the workspace environment **100** may encompass a plurality of workspaces **105**. Further, the airborne contaminants **120** may be any form of contaminants including, but not limited to, droplets, fumes, mists, vapors, dust, virus particles, disease molecules, bacterium, or other types of pathogens, that may be transmitted from a source **130** of the airborne contaminants **120** within the workspace **105**. In an example, as shown in FIG. **1**, the source **130** of transmission of the airborne contaminants **120** is a patient seated within the workspace **105**. However, it may be contemplated that the source **130** may be any living or non-living entity including, but not limited to another person, such as a practitioner **110**, (for example, a dentist as illustrated), an animal, such as a pet (not shown), or a machine, such as an air circulator (not shown) present within the workspace **105**.

Referring to both FIG. **1** and FIG. **2**, the workspace environment **100** includes the system **200** for protecting the workspace **105** from the airborne contaminants **120** transmitted from the source **130** in the workspace **105**. The system **200** may be an independent system that may be added to existing operating setups in the workspace **105** to protect the workspace **105** from the airborne contaminants **120**. Alternatively, the system **200** may be integrated with the specific operations' environment of the workspace **105**, for example, within a procedure table or chair **150** (for example, a dental chair as illustrated).

As depicted in FIGS. **1** and **2**, the system **200** may include a sensing capturing unit **205**, an air transmission unit **210**, an air capturing unit **215**, and a processor **235** operatively coupled to one another via one or more buses or other wired or wireless connections, as is known in the art. As shown in FIG. **2**, the system **200** may also include an input/output unit **220**, a sensor unit **225**, a memory **240**, and a filter unit **230** operatively coupled to the processor **235** via one or more buses or other wired or wireless connections, as is known in the art. Although the memory **240** and the processor **235** are shown as separate units in FIG. **2**, it will be appreciated that the memory **240** and the processor **235** can be implemented together as a standalone computing system in some embodiments. Additionally, in some embodiments, the memory **240** may be formed as a part of other devices, such as the practitioner's cellular telephone or any other computing device, present in the workspace **105**. Although not shown, in some embodiments, the system **200** may include a plurality of each of the sensing capturing units **205**, the air transmission units **210**, the air capturing units **215**, and the filter units **230** depending upon the layout, the size, and other features of the workspace **105**.

The sensing capturing unit **205** in some embodiments is an image sensing unit, an electromagnetic detection unit, a thermal capturing unit, a chemical capturing unit, or any other sensing capturing unit now known or later developed. The sensing capturing unit **205** is adapted to capture a sensing data associated with the workspace **105** and transmit the captured sensing data associated with the workspace **105** to the processor **235**. As shown, the sensing capturing unit **205** may be operatively coupled to the processor **235**. The sensing capturing unit **205** may be positioned within the workspace **105** to capture the sensing data associated with the workspace **105**. For instance, in the exemplary implementation shown in FIG. **1**, the sensing capturing unit **205** is vertically mounted on the ceiling within the workspace **105** to capture the sensing data of the workspace **105**. The sensing capturing unit **205** may be a camera or any other device capable of capturing the sensing data of the workspace **105**. The sensing data may include a sequence of images of the workspace **105** captured by the sensing capturing unit **205** over a period of time and/or any data associated with the sequence of the images of the workspace **105** captured by the sensing capturing unit **205** over the period of time. Examples of the images may include, but not limited to, two-dimensional images, three-dimensional images, and so on. For instance, in the exemplary implementation shown in FIG. **1**, the images of the workspace **105** may include the images of a plurality of components, such as, the source **130**, the practitioner **110**, the chair **150**, a light **155**, and others, present within the workspace **105**. In some embodiments, depending upon the layout, the size, and other features of the workspace **105**, the system **200** may include more than one sensing capturing units **205**, spaced a distance apart from one another in the workspace **105** to capture the sensing data of an entire area of the workspace **105**.

The processor **235** is configured to receive the sensing data associated with the workspace **105** from the sensing capturing unit **205** and determine presence of at least one source **130** of transmission of the airborne contaminants **120** in the workspace **105** based on the received sensing data. The processor **235** may be located within or remotely with respect to the workspace **105**. For instance, the processor **235** has been shown and described to be positioned remotely with respect to the workspace **105** in the exemplary implementation, as shown in FIG. **1**, however it will be appreciated that the processor **235** may be positioned within the workspace **105**, in alternative embodiments.

In accordance with various embodiments, the processor **235** may be configured to determine the presence of the source **130** of transmission of the airborne contaminants **120** based on the sensing data by employing various machine vision techniques. In an exemplary embodiment, the processor **235** is configured to analyze the received sensing data to determine physical characteristics of the plurality of components such as, the source **130**, the practitioner **110**, the chair **150**, and the light **155** in the sensing data. The processor **235** may further be configured to identify one or more components, from the plurality of components, located within predefined areas in the sensing data. The predefined areas may be defined as areas where the source **130** of transmission of the airborne contaminants **120** is likely to be present. In the illustrated embodiment, the predefined area may include the area above the chair **150** and the one or more components located within the predefined areas may include the patient. The processor **235** may be further configured to compare the physical characteristics of the identified one or more components within the predefined areas with predetermined physical characteristics associated

with known sources of transmission of airborne contaminants. The processor **235** may then be configured to identify a component, from the one or more components, as the source **130** of the transmission of the airborne contaminants **120** when the physical characteristics of the component match the predetermined physical characteristics associated with the known sources of transmission of airborne contaminants. In the exemplary implementation, the processor **235** may compare the physical characteristics of the patient with the predetermined physical characteristics associated with known sources (such as, a human) and identifies the patient as the source **130** of transmission of the airborne contaminants **120** when the physical characteristics of the patient match the predetermined physical characteristics of the human. In some embodiments, the processor **235** may be further configured to identify the mouth and nose of the patient as a point of transmission of the airborne contaminants **120** from the source **130**, using various machine vision techniques, such as object detection and face recognition techniques, now known or future developed.

The processor **235** may additionally use Artificial Intelligence (AI) based techniques, now known or future developed, to identify the source **130** within the sensing data. For example, in some embodiments, the processor **235** will set an initial configuration associated with the workspace **105**. Thereafter, the processor **235** may use artificial intelligence techniques in a continuous loop for real-time feedback and training of source identification. The processor **235** continually evolves the specifics in real time with new inputs to continually optimize techniques to identify the source **130** over time.

Although the machine vision technique is described herein to determine the presence of the source(s) of transmission of the airborne contaminants, other techniques for determining the presence of the source(s) of transmission of the airborne contaminants in the workspace **105** may also be used in alternative implementations.

In one embodiment, the processor **235** is adapted to configure a capture zone **135** within the workspace **105** based on the determined source **130** of transmission of the airborne contaminants **120**. The capture zone **135** may be an area suspected to be infected with the airborne contaminants **120** transmitted from the determined source **130** in the workspace **105**. The capture zone **135** may also be defined as an area/zone that is to be secured and rendered harmless in order to protect the workspace **105** from the airborne contaminants **120**. For example, the capture zone **135** may be defined as an area within a predetermined radial distance from and around the source **130**, in this case, front and sides of the mouth and nose of the determined source **130** of the airborne contaminants **120**. In some embodiments, the predetermined radial distance corresponds to a minimum separation distance required from the source **130** of transmission of the airborne contaminants **120**, such as the patient, to protect others from getting infected by the airborne contaminants **120** transmitted from the source **130**. The predetermined radial distance may be predefined according to the specific requirements of the workspace **105**. For example, the predetermined radial distance may be set corresponding to the layout, the size and other features of the workspace **105**. In one non limiting example, the predetermined radial distance may be predefined as one (1) meter from the front and sides of the mouth and nose of the determined source **130** of the airborne contaminants **120**. Accordingly, the capture zone **135** may be defined so as to cover this predetermined area around the source **130**. As depicted in FIG. **1**, the capture zone **135** may be conical in shape. Alternatively, the capture zone **135** may be configured to be of any other shape, including rectangular, circular, and the like.

In some embodiments, the processor **235** may be configured to define exclusion and/or inclusion areas based on a location of the determined source **130** of the airborne contaminants **120** in the workspace **105**. The inclusion areas may include areas suspected to be including the airborne contaminants **120**, while the exclusion areas may include areas free from the airborne contaminants **120**. For example, the inclusion area may include, but not limited to, an area adjacent to the mouth and nose of the source **130** of the airborne contaminants **120** and the exclusion area may include, but not limited to, an area away from the source **130** of the airborne contaminants **120**. In some embodiments, the processor **235** may be adapted to configure the capture zone **135** based on the defined exclusion and/or inclusion areas. In some embodiments, the processor **235** may be adapted to configure the capture zone **135** to include all inclusion areas. In some alternative embodiments, the processor **235** configures the capture zone to include all inclusion areas and few exclusion areas.

In accordance with various embodiments, the processor **235** may be further adapted to adjust the configured capture zone **135** based on an operating state of one or more devices operable within the workspace **105**. The operating state of each of the one or more devices may define the active or inactive state of the device. To this end, the processor **235** may be adapted to detect the one or more devices within the workspace **105**, along with the operating state of each of the detected one or more devices. In some embodiments, when the system **200** is integrated with the specific operations' environment of the workspace **105**, the one or more devices may each be individually communicatively coupled to the processor **235** and the processor **235** may be configured to determine an operating state of each of the one or more devices based on signals received from the one or more devices. The signals received from the one or more devices may include the identification information of the corresponding device along with other information indicative of the operating state of the associated device. In yet other embodiments, when the system **200** is added as add-on to the existing operating setups, the processor **235** may be configured to determine the identification information and the operating state of the one or more devices based on various machine vision techniques applied on the sensing data generated by the sensing capturing unit **205**.

In some scenarios, the airborne contaminants (shown by reference numeral **120'** in FIG. **3**) may spread to a larger area due to a change in the operating state of a device present within the workspace **105**. For example, when a device, such as an air gun **305** is activated and being operated on the source **130** of the airborne contaminants, such as the patient, the intensity of flow of air escaping from the mouth and nose of the source **130** increases thereby causing the airborne contaminants **120'** to spread to the larger area as compared to the previously configured area of the capture zone **135**, as illustrated in FIG. **3**. To this end, the processor **235** may be configured to adjust the capture zone **135** to a capture zone **135'** (as shown in FIG. **3**) to include the larger area with the airborne contaminants **120'**. In some embodiments, the processor **235** may be configured to determine the configuration of the capture zone **135'** based on predefined and pre-stored configurations corresponding to the identification information of the activated one or more devices in the memory **240**. The memory **240**, as shown in FIG. **5**, may be configured to store various configurations for capture zones corresponding

to various operating states of the one or more devices operable within the workspace **105**. For instance, the memory **240** may store positional information **515** of the capture zone **135'** corresponding to an operating state **505** of each of the one or more devices within the workspace **105**. The positional information **515** of the capture zone **135'** may include the position coordinates (X, Y, Z coordinates) and the size (for example, an area A1) of the capture zone **135'**. The processor **235** may be further configured to adjust the capture zone **135** to the capture zone **135'** according to the predefined configurations of capture zone **135'** stored in the memory **240** to capture the airborne contaminants **120'** when the air gun **305** is detected to be in active state by the processor **235**.

Furthermore, the capture zone **135'** may be different for different devices within the workspace **105** and may be determined based on operating characteristics of the activated one or more devices in the workspace **105**. For instance, the capture zone **135'** associated with the usage of the air gun **305** may be larger than a capture zone associated with the usage of dental syringe, as the flow of air escaping from the mouth and nose of the patient due to the usage of the air gun **305** may be greater as compared to the flow of air escaping from the mouth and nose of the patient when the dental syringe is used.

In some embodiments, the positional information **515** of the capture zone **135**, **135'** may be stored as separate operating profiles in the memory **240**. To this end, the memory **240** of the system **200** may be configured to store data **500** (as shown in FIG. **5**) associated with each of the one or more devices operational within the workspace **105**. For example, the data **500** may include the operating state **505** of each of the one or more devices and an operating profile **510** of the workspace **105** based on the operating state **505** of each of the one or more devices. For example, when the operating state of all devices in the workspace **105** represent inactive state, the operating profile **510** of the workspace **105** may be referred to as a resting profile. Similarly, when the operating state of the one or more devices, such as the air gun **305** (shown in FIG. **3**) in the workspace **105** represents active state, the operating profile **510** of the workspace **105** may be referred to as the air gun profile. The memory **240** may be further configured to store the positional information **515** of the capture zone **135'** for each operating profile **510** of the workspace **105**. In some embodiments, the positional information **515** corresponding to the operating state **505** of each of the one or more devices within the workspace **105** and/or the operating profile **510** are calibrated and validated before being stored in the memory **240**. In such embodiments, the processor **235** may be first configured to determine the operating profile **510** of the workspace **105** and the positional information **515** of the capture zone **135'** based on the determined operating state **505** of the one or more devices. The processor **235** may further be configured to adjust the capture zone **135** to the capture zone **135'** based on the determined positional information **515**. In an embodiment, the components of the system **200** may be calibrated and validated during the initial set-up in the workspace **105** so as to accurately configure the capture zone **135** corresponding to the layout, the size and other features of the workspace **105**.

In accordance with various embodiments, the processor **235** may be configured to alternatively or additionally adjust the capture zone **135**, **135'** based on a distribution pattern of the airborne contaminants within the workspace **105**, as illustrated in FIG. **4**. In some scenarios, the airborne contaminants (as shown by reference numeral **120"** in FIG. **4**) may also be present outside the capture zone **135**, **135'**, such as due to malfunctioning of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** of the system **200**, or activation of additional equipment (such as, an air conditioner or an air fan) that cause the airborne contaminants **120**, **120'** to spread outside the capture zone **135**, **135'**, or some unexpected circumstances, or any other known or unknown reasons. To protect the workspace **105** from the airborne contaminants **120"** that do not lie within the capture zone **135**, **135'**, the processor **235** may be configured to determine the distribution pattern of the airborne contaminants **120"** in the workspace **105** and adjust the capture zone **135**, **135'** to a capture zone **135"** to include an area with the airborne contaminants **120"** based on the determined pattern.

To this end, the sensor unit **225** is operatively coupled to the processor **235**. The sensor unit **225** may be configured to detect the presence of the airborne contaminants **120"** in the workspace **105**. The sensor unit **225** may be positioned anywhere within the workspace **105**. For example, the sensor unit **225** may be positioned closer to areas suspected to be infected with the airborne contaminants, such as near the chair **150**. Alternatively, the sensor unit **225** may be positioned overhead the chair **150**, such as near the light **155**. Examples of the sensor unit **225** may include, but not limited to, one or more of a thermal sensor, internet of things (IoT) sensors, a vapor sensor, a chemical sensor, a visual sensor, and a biological sensor.

The processor **235** may be configured to determine the distribution pattern of the airborne contaminants **120"** in the workspace **105** based on the detected presence of the airborne contaminants **120"** and further determine whether the detected airborne contaminants **120"** are captured within the configured capture zone **135**, **135'**. If the detected airborne contaminants **120"** are determined to be captured within the configured capture zone **135**, **135'**, the processor **235** may not adjust the capture zone **135**, **135'** any further. However, if the detected airborne contaminants **120"** are determined to be present outside and not captured within the configured capture zone **135**, **135'**, the processor **235** may be configured to further adjust the previously configured capture zone **135**, **135'** to the capture zone **135"** (as shown in FIG. **4**) so as to include the airborne contaminants **120"**. In accordance with various embodiments, the processor **235** may be configured to continuously detect the distribution pattern of the airborne contaminants **120"** in the workspace **105** and adjust the capture zone **135**, **135'** to capture the airborne contaminants **120"** within the adjusted capture zone **135"**, in real time. In some embodiments, a positional information of the adjusted capture zone **135"** may be stored in the memory **240**, for future reference and use.

In an embodiment, the processor **235** is further configured to control the air transmission unit **210** to direct a unidirectional flow of air **140**, **140'**, **140"** over the configured capture zone **135**, **135'**, **135"** (as shown in FIGS. **1**, **3**, and **4**). In accordance with various embodiments, the air transmission unit **210** may be adapted to direct the unidirectional flow of air **140**, **140'**, **140"** over the capture zone **135**, **135'**, **135"** and direct movement of the airborne contaminants **120**, **120'**, **120"** in the capture zone **135**, **135'**, **135"** towards the air capturing unit **215** positioned opposite to the air transmission unit **210** within the workspace **105**.

Referring back to FIGS. **1** and **2**, in an exemplary embodiment, the air transmission unit **210** may be operatively coupled to the processor **235**. The air transmission unit **210** includes a conduit **212**, an air nozzle controller **214**, a fan **216**, a disinfectant storage container **218**, and one or more nozzles **222**. In some implementations, the fan **216** and the

one or more nozzles **222** may be positioned anywhere within the workspace **105**, depending upon the requirement of the workspace environment **100**. In the exemplary implementation, as illustrated, the fan **216** and the one or more nozzles **222** may be positioned above the head of the patient sitting on chair **150**. The conduit **212** may be concealed and positioned outside the workspace **105**, such as in the walls and false ceiling of the workspace environment **100**, as shown in FIG. **1**.

The fan **216** and the one or more nozzles **222** are fluidly coupled to the conduit **212**, and the processor **235** may be configured to control the fan **216** to draw air in from an environment outside the workspace **105** through the conduit **212** and generate a flow of air through the one or more nozzles **222**. In an exemplary embodiment, the processor **235** may be configured to direct the flow of air generated by the fan **216** unidirectionally through the one or more nozzles **222** over the capture zone **135**, **135'**, **135"** so as to entirely cover the capture zone **135**, **135'**, **135"**, as shown in FIGS. **1**,**3**, and **4**. In accordance with various embodiments, the unidirectional flow of air **140**, **140'**, **140"** directed over the capture zone **135**, **135'**, **135"** directs the movement of the airborne contaminants **120**, **120'**. **120"** present in the configured capture zone **135**, **135'**, **135"** towards the air capturing unit **215**, thereby forming an air curtain over the capture zone **135**, **135'**, **135"**. In the embodiment, as shown in FIGS. **1**, **3**, and **4**, the unidirectional flow of air **140**, **140'**. **140"** is indicated as diagonal flow of air. However, it may be contemplated that depending on the positioning of the air transmission unit **210** and the air capturing unit **215**, the unidirectional flow of air **140**, **140'**, **140"** may include vertical or horizontal flow of air, without deviating from the scope of the claimed subject matter. In some embodiments, when the additional equipment (such as, the air conditioner or the air fan) that may impact the movement of the airborne contaminants **120**, **120'**, **120"** are present within the workspace **105**, the processor **235** may be configured to adjust the capture zone **135**, **135'**, **135"** to capture an area with the airborne contaminants **120**, **120'**, **120"** and then direct the unidirectional flow of air **140**, **140'**, **140"** over the adjusted capture zone to direct the airborne contaminants **120**, **120'**, **120"** towards the air capturing unit **215**.

In some embodiments, the processor **235** may also be configured to determine one or more operating parameters of the one or more nozzles **222** and adjust the same according to the configured capture zone **135**, **135'**, **135"**. To this end, as shown in FIG. **5**, the memory **240** may also be configured to store operating parameters **520** of the one or more nozzles **222** corresponding to each operating profile **510** of the workspace **105**. The operating parameters of the one or more nozzles **222** may include, but not limited to, data related to an angle (for example, A**1**), a height (for example, H**1**), and an intensity (for example, I**1**) at which the one or more nozzles **222** should operate to direct the unidirectional flow of air **140**, **140'**, **140"** over the capture zone **135**, **135'**, **135"**. For example, the operating parameters **520** of the one or more nozzles **222** may be defined based on the positional information of the capture zone **135**, **135'**, **135"** so as effectively generate the flow of air **140**, **140'**. **140"** that successfully directs the airborne contaminants **120**, **120'**, **120"** in the capture zone **135**, **135'**, **135"** towards the air capturing unit **215**. In some alternative embodiments, the processor **235** may also selectively activate and deactivate one or more nozzles within the one or more nozzles **222** to adjust the flow of air according to the configured capture zone. In some embodiments, operating parameters of the one or more nozzles **222** corresponding to the operating state **505** of each of the one or more devices within the workspace **105** and/or the operating profile **510** are calibrated and validated before being stored in the memory **240**.

The processor **235** may be configured to determine the operating parameters **520** of the one or more nozzles **222** corresponding to the operating profile **510** of the workspace **105** based on the data **500** stored in the memory **240** and control the air nozzle controller **214** to adjust the one or more nozzles **222** based on the determined operating parameters **520**. The air nozzle controller **214** may be configured to, in turn, individually control each of the one or more nozzles **222**, for example, the angle, the height, and the intensity of each of the one or more nozzles **222**. The air nozzle controller **214** may be located within or outside the workspace **105**. Once all the nozzles **222** are adjusted according to the determined operating parameters **520**, the processor **235** may be configured to control the air nozzle controller **214** to direct the flow of air **140**, **140'**, **140"** generated by the fan **216** unidirectionally over the capture zone **135**, **135'**. **135"** through the one or more nozzles **222**.

Further, in some embodiments, the processor **235** may also be configured to adjust the operating parameters **520** of the one or more nozzles **222** based on the determined distribution pattern of the airborne contaminants **120**, **120'**, **120"** present in the workspace **105**. For instance, the processor **235** may be configured to determine that the at least one of the operating parameters **520** of the one or more nozzles **222** be adjusted by a first predefined amount when the distribution pattern of the airborne contaminants **120**, **120'**, **120"** represent that a density of the airborne contaminants **120**, **120'**, **120"** in the capture zone **135**, **135'**, **135"** is greater than or equal to a threshold value. In such a scenario, for example, the intensity (such as, the speed, the range, and the pressure etc.) of flow of air **140**, **140'**, **140"** directed from the one or more nozzles **222** may be increased to effectively remove the airborne contaminants **120**, **120' 120"** from the capture zone **135**, **135'**, **135"**. In another example when the determined distribution pattern of the airborne contaminants **120**, **120'**, **120"** indicates a narrow spread of contaminants but the density of contaminants is high, then the processor **235** may adjust the angle and intensity of the one or more nozzles **222**, and/or selectively activate only a few of the one or more nozzles **222** to direct a narrow and high intensity flow of air over the capture zone.

In some embodiments, the processor **235** may be configured to control the disinfectant storage container **218** in the air transmission unit **210** to disperse disinfectant over the capture zone **135**, **135'**, **135"**. The disinfectant storage container **218** may be configured to store and inject disinfectants, such as chemicals, for disinfecting the airborne contaminants **120**, **120'**, **120"** present in the workspace **105**. The disinfectant storage container **218** may be positioned within or outside the workspace **105**. In accordance with various embodiments, the processor **235** may be configured to control the disinfectant storage container **218** in the air transmission unit **210** to disperse disinfectant, along with the unidirectional flow of air **140**, **140'**, **140"**, through the one or more nozzles **222** over the capture zone **135**, **135'**, **135"**. The disinfectant dispensed along with the unidirectional flow of air **140**, **140'**, **140"** transmits over the capture zone **135**, **135'**, **135"** and disinfects the airborne contaminants **120**, **120'**, **120"** present in the capture zone **135**, **135'**, **135"**.

The processor **235** may be further configured to control the air capturing unit **215** to capture the unidirectional flow of air **140**, **140'**, **140"** along with the airborne contaminants **120**, **120'**, **120"** directed from the air transmission unit **210**. The air capturing unit **215** may be adapted to receive the

unidirectional flow of air **140**, **140'**, **140"** directed from the one or more nozzles **222** of the air transmission unit **210**. In accordance with various embodiments, the air capturing unit **215** may be operatively coupled to the processor **235**. The air capturing unit **215** may be positioned opposite and in line with the air transmission unit **210** to receive the unidirectional flow of air **140**, **140'**, **140"** directed from the one or more nozzles **222** of the air transmission unit **210**. The air capturing unit **215** may be positioned anywhere within the workspace **105**, for example, on a side wall shown in FIG. **1**. However, in some alternative embodiments, the air capturing unit **215** may also be positioned closer to the source **130**, such as closer to the chest of the patient, so as to reduce the length of the air curtain and thus, immediately capture the airborne contaminants **120**, **120'**, **120"** transmitted from the source **130**. Further, the size of the air capturing unit **215** may be varied depending upon the requirements of the workspace **105**. In some embodiments, the air capturing unit **215** may be sized to cover a single chair **150** (as shown in FIG. **1**), while in alternative embodiments, the air capturing unit **215** may be sized to cover multiple chairs in the workspace **105**. In some other embodiments, the air capturing unit **215** may be positioned via a moveable mounting system that may facilitate adjustment of the air capturing unit **215** as and when required.

In an embodiment, the air transmission unit **210** and the air capturing unit **215** of the system **200** may be calibrated and validated during the initial set-up in the workspace **105** so as to accurately generate the flow of air **140**, **140'**, **140'** over the capture zone **135**, **135'**, **135"** corresponding to the layout, the size and other features of the workspace **105**. In an exemplary embodiment, the air capturing unit **215** may be a vacuum or a suction unit configured to draw the unidirectional flow of air **140**, **140'**, **140"** directed from the one or more nozzles **222** along with the airborne contaminants **120**, **120'**, **120"** from the capture zone **135**, **135'**, **135"**. In some embodiments, the processor **235** may be configured to control the air nozzle controller **214** to electrically charge or polarize air ions in the unidirectional flow of air **140**, **140'**, **140"** directed towards the capture zone **135**, **135'**, **135"**. In some embodiments, the electrically charged or polarized air ions are generated by placing electrically charged materials adjacent to the one or more nozzles **222**. The electrically charged or polarized air ions attach to the airborne contaminants **120**, **120'**, **120"** present in the capture zone **135**, **135'**, **135"** and force the airborne contaminants **120**, **120'**, **120"** to enter the air capturing unit **215**. In some embodiments, the air capturing unit **215** may also include electrically and opposite charged materials to capture the electrically charged or polarized air ions attached to the airborne contaminants **120**, **120'**, **120"**.

In some embodiments, the air capturing unit **215** may also include an air storage container **224** to store air samples collected from the captured flow of air **140**, **140'**, **140"** along with the airborne contaminants **120**, **120'**, **120"**. In accordance with various embodiments, the processor **235** may be configured to control the air capturing unit **215** to store air samples from the captured flow of air **140** along with the airborne contaminants **120**, **120'**, **120"** in the air storage container **224**. In some embodiments, the stored air samples may be stored with other relevant parametric data, such as, time, date, and identification information of the individuals present in the workspace **105** and the collected sample. These stored air samples may be maintained for each patient for various purposes, such as archival, test, investigation, tracing, further analysis, or record. For example, these samples may be used subsequently to test and determine the type of contaminants transmitted by the source **130**. The processor **235** may communicate such information to the patient, in some embodiments, to alert them of any potential disease or infection based on the determined type of contaminant. Such information may also facilitate tracing of potential transmission sources in case of epidemic or pandemic like situations.

In some embodiments, the filter unit **230** may be configured to receive the unidirectional flow of air **140**, **140'**, **140"** along with the airborne contaminants **120**, **120'**, **120"** captured by the air capturing unit **215** through a conduit **255** fluidly connected to the air capturing unit **215**. The filter unit **230** may be operatively coupled to the processor **235** and located within or remotely with respect to the workspace **105**. Upon receiving the unidirectional flow of air **140**, **140'**, **140"** along with the airborne contaminants **120**, **120'**, **120"**, the processor **235** may be configured to control the filter unit **230** to disinfect the captured airborne contaminants **120**, **120'**, **120"**. To this end, the processor **235** may be configured to determine types of the captured airborne contaminants **120**, **120'**, **120"**, using the filter unit **230**. In some embodiments, the determined types of the captured airborne contaminants **120**, **120'**, **120"** may include toxicity and risk level of the captured airborne contaminants. Further, the processor **235** may be configured to control the filter unit **230** to disinfect the captured airborne contaminants **120**, **120'**, **120"** based on the determined types of the captured airborne contaminants **120**, **120'**, **120"**. In an exemplary embodiment, the filter unit **230** may be configured to disinfect the captured airborne contaminants **120**, **120'**, **120"** using appropriate disinfectants, such as, but not limited to, chemical disinfectants (such as alcohol, antiviral solutions), ultraviolet (UV) lights, thermal disinfection, or other filtration methods now known or future developed. In accordance with various embodiments, the filter unit **230** is designed to withstand repeated cycles of (chemical, light, and thermal) treatment to be reusable, or replaceable.

In some embodiments, the filtered air from the filter unit **230** may be recirculated back into the workspace **105**. In alternative embodiments, the filtered air from the filter unit **230** may be released in the environment outside the workspace **105**. In accordance with some embodiments, the captured airborne contaminants **120**, **120'**, **120"** are disinfected until the maximal tolerance limit of the airborne contaminants **120**, **120'**, **120"** is exceeded, before the treated air is recycled and released. In some embodiments, the treated air may subsequently be tested for safety, using the testing unit **260**, prior to release or recirculation. In accordance with some embodiments, the testing unit **260** may be configured to test the treated air based on specific requirements for the workspace **105** and various standard regulations that may emerge in the future for the workspace **105**. In yet other alternative embodiments, the filtered air from the filter unit **230** may be stored in a storage unit (not shown) for further treatment and processing.

In some embodiments, the processor **235** may be configured to configure treatment fields between the air transmission unit **210** and the air capturing unit **215**, depending upon the types of the airborne contaminants **120**, **120'**, **120"**. To this end, the processor **235** may be configured to determine, using the filter unit **230**, a type of airborne contaminants **120**, **120'**, **120"** present in the workspace **105**. The processor **235** may be further configured to determine the distribution pattern of the airborne contaminants **120**, **120'**, **120"** based on data received from the sensor unit **225**. Depending upon the type and the distribution pattern of the airborne contaminants **120**, **120'**, **120"**, the processor **235** may be adapted

to configure treatment fields between the air transmission unit **210** and the air capturing unit **215** to disinfect the airborne contaminants **120**, **120'**, **120"**. In accordance with some embodiments, the treatment fields are configured to provide one or more of the ultraviolet radiations, thermal heat, or other treatment techniques to disinfect the airborne contaminants **120**, **120'**, **120"**. In some embodiments, the processor **235** may be configured to use machine learning models to continuously adjust the characteristics, such as light intensity, temperature etc., of the treatment fields in real time based upon the type and the distribution pattern of the airborne contaminants **120**, **120'**, **120"**, as described in detail in the forthcoming disclosure.

In some embodiments, the processor **235** may be configured to periodically monitor the operational status of the various components of the system **200**. For instance, the processor **235** may be configured to regularly monitor the operational status of each of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** to detect malfunctioning of any one or more of these components. In accordance with various embodiments, the malfunctioning of a unit may be defined as a state when an operating performance of the corresponding unit falls below a defined performance threshold value or when the operating profile **510** of the workspace **105** stray from the operating profile **510** defined in the memory **240**. The operating performance is the degree of effectiveness by which the respective units are functioning. For example, the processor **235** may be configured to determine the degree of effectiveness of the filter unit **230** by installing a testing unit **260** in the filter unit **230** to determine whether the captured airborne contaminants **120**, **120'**, **120"** are successfully disinfected. Similarly, the processor **235** may be configured to determine the degree of the effectiveness of the air transmission unit **210** and the air capturing unit **215** by installing various sensors in the air transmission unit **210** and the air capturing unit **215**. For example, a first pressure sensor (not shown) may be installed in the air transmission unit **210** to determine whether the required intensity of flow of air is generated by the air transmission unit **210**. Similarly, a second pressure sensor (not shown) may be installed in the air capturing unit **215** to determine whether the required intensity of flow of air is captured by the air capturing unit **215**. The processor **235** may then be configured to determine whether the effectiveness of any of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** has fallen below the defined performance threshold value. If the processor **235** determines that the effectiveness of any of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** has fallen below the defined performance threshold value, the processor **235** identifies the corresponding unit that has malfunctioned and generates an alert indicative of the detected malfunctioning using the input-output unit **220** located within the workspace **105**. Examples of the alerts may include, but not limited to, an audio alert, visual alert, textual alert, and so on. Such information and alerts may be subsequently used to run diagnostics on the system **200** and facilitate repair of the one or more malfunctioned components.

In some embodiments, the processor **235** may preemptively switch to safe operating profiles, such as the resting profile, in case any malfunctioning of one of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** is detected. For example, the processor **235** may prevent or recommend against, via alerts, any unintended activation of aggressive operations (i.e., blow of excessive air, splash of high-pressure water, drilled particles that falls outside the capture zone **135**, **135'**, **135"** and so on) from the one or more devices within the workspace **105**.

In some embodiments, the processor **235** may be configured to control the operating state of the one or more devices when the malfunctioning of any one or more of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** is detected. For example, the processor **235** may be configured to change or recommend changes, via alerts, to the operating state of the devices in the workspace **105** to inactive state, to avoid any further transmission of the airborne contaminants **120"** when the processor **235** detects the malfunctioning of one or more of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230**.

In alternative embodiments, the processor **235** may also be configured to control operating characteristics of the one or more devices in order to avoid transmission of the airborne contaminants **120**, **120'**, **120"** outside the capture zone **135**, **135'**, **135"**. The operating characteristics may include pressure of flow of air generated by the device, pressure of flow of water generated by the device, power state at which the device is being operated, and so on. For example, in some embodiments, after the capture zone **135**, **135'**, **135"** is configured or adjusted, a change in the operating characteristics of a device may change the flow of air escaping from the mouth and nose of the source **130** of the airborne contaminants **120**, **120'**, **120"**, thereby causing the airborne contaminants **120**, **120'**, **120"** to be transmitted outside the capture zone **135**, **135'**. **135"** in some cases. For example, an increase in the pressure of flow of air generated by the air gun **305** may also increase the flow of air escaping from the mouth and nose of the patient and cause the airborne contaminants **120**, **120'**, **120"** to be transmitted outside the capture zone **135**, **135'**, **135"**. To avoid any such situation, the processor **235** may be configured to control the operating characteristics of the one or more devices, such as the air gun **305**, within a predefined limit, so that any unexpected change in the operating characteristics of the one or more devices does not cause the airborne contaminants **120**, **120'**, **120"** to be transmitted outside the capture zone **135**, **135'**, **135"**.

In some embodiments, the processor **235** may be configured to use machine learning models to create new operating profiles and/or adjust the existing operating profiles **510**. The processor **235** may further be configured to define/adjust the positional information **515** of the capture zone **135**, **135'**, **135"** and the operating parameters **520** for the one or more nozzles **222** for each of the new and adjusted operating profiles **510**. To this end, the processor **235** may additionally include a machine learning module **250** configured to be trained for detecting the machine operations by using one or more machine learning algorithms.

The machine learning module **250** may be configured to execute the instruction stored in the memory **240**, to perform one or more predetermined operations. The machine learning module **250** may be a data processor and/or a mainframe employing artificial intelligence (AI) to perform the one or more predetermined operations, in accordance with some embodiments. In some embodiments, the machine learning module **250** may be implemented separately as a different unit from the processor **235** in the system **200**. However, in some alternative embodiments, the machine learning module **250** may be a specially constructed computing platform for carrying out the predetermined operations as described herein. The machine learning module **250** may be implemented or provided with a wide variety of components or

systems (not shown), including one or more of memories, registers, and/or other data processing devices and subsystems.

The machine learning module **250** may be any system configured to learn and adapt itself to do better in changing environments. The machine learning module **250** may employ any one or combination of the following computational techniques: neural network, constraint program, fuzzy logic, classification, conventional artificial intelligence, symbolic manipulation, fuzzy set theory, evolutionary computation, cybernetics, data mining, approximate reasoning, derivative-free optimization, decision trees, and/or soft computing. In an exemplary embodiment, the machine learning module **250** may employ a random forest algorithm to learn and adapt itself.

The machine learning module **250** may implement an iterative learning process. The learning may be based on a wide variety of learning rules or training algorithms. The learning rules may include one or more of back-propagation, patter-by-pattern learning, supervised learning, and/or interpolation. As a result of the learning, the machine learning module **250** may learn to operate in the workspace **105**.

The machine learning module **250** may be configured to receive a training data set comprising the data **500** associated with the operating state **505** of each of the one or more devices, the operating profile **510** of the workspace **105**, the positional information **515** of the capture zone **135'**, and the operating parameters **520** for the one or more nozzles **222**. The machine learning module **250** may be configured to learn by correlating the data **500** associated with the operating state **505** of each of the one or more devices, the operating profile **510** of the workspace **105**, the positional information **515** of the capture zone **135'**, and the operating parameters **520** for the one or more nozzles **222**. In an embodiment, the machine learning module **250** may be configured to determine one or more correlations between the data **500** associated with the operating state **505** of each of the one or more devices, the operating profile **510** of the workspace **105**, the positional information **515** of the required capture zone **135'**, and the operating parameters **520** for the one or more nozzles **222**.

The machine learning module **250** may be configured to create new operating profiles **510** based on the combination of the operating state of one or more devices or any newly installed additional devices in the workspace **105**. The machine learning module **250** may further be configured to define the positional information **515** of the required capture zone **135'** and the operating parameters **520** for the one or more nozzles **222** for each of the new operating profiles **510**, based on the determined one or more correlations. The processor **235** may then be configured to adjust the capture zone **135** according to determined new operating profiles **510** and the operating parameters of the one or more nozzles **222** in accordance with the operating parameters as determined by the machine learning module **250**.

In some embodiments, the processor **235** may be configured to validate the configuration of the capture zone **135**, **135'**, **135'** and the operating parameters of the one or more nozzles **222** determined by the machine learning module **250** to ensure that the workspace **105** is protected from the airborne contaminants **120**, **120'**, **120"**. To this end, the processor **235** may be configured to provide data associated with the distribution pattern of the airborne contaminants **120**, **120'**, **120"** in the workspace **105** to the machine learning module **250** on a periodic basis.

In some embodiments, the machine learning module **250** may be configured to receive a predefined training data set comprising the type of the airborne contaminants **120**, **120'**, **120"**, the distribution pattern of the airborne contaminants **120**, **120'**, **120"**, and the characteristics of the treatment field. The machine learning module **250** may be configured to learn by correlating the data associated with the type of the airborne contaminants **120**, **120'**, **120"**, the distribution pattern of the airborne contaminants **120**, **120'**, **120"**, and the characteristics of the treatment field. In an embodiment, the machine learning module **250** may be configured to determine one or more correlations between the type of the airborne contaminants **120**, **120'**, **120"**, the distribution pattern of the airborne contaminants **120**, **120'**, **120"**, and the characteristics of the treatment field.

The machine learning module **250** may be configured to define characteristics of the thermal fields for a particular type and a distribution pattern of the airborne contaminants **120**, **120'**, **120"** based on the determined one or more correlations. The processor **235** may then be configured to continuously adjust the characteristics of the thermal fields in real time according to the characteristics determined by the machine learning module **250**.

In accordance with various embodiments, the memory **240** may include a random access memory (RAM) and read only memory (ROM). The RAM may be implemented by Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), and/or any other type of random access memory device. The ROM may be implemented by a hard drive, flash memory and/or any other desired type of memory device.

Further, the processor **235** may be configured to execute the instruction stored in the memory **240**, to perform the one or more predetermined operations, such as those described herein. The processor **235** may include one or more microprocessors, microcontrollers, DSPs (digital signal processors), state machines, logic circuitry, or any other device or devices that process information or signals based on operational or programming instructions. The processor **235** may be implemented using one or more controller technologies, such as Application Specific Integrated Circuit (ASIC), Reduced Instruction Set Computing (RISC) technology, Complex Instruction Set Computing (CISC) technology, etc.

The input/output unit **220** may be positioned within or remotely with respect to the workspace **105**. The input/output unit **220** may include a graphical user interface (such as, a mobile phone, a tablet, a touch screen computer) or other input/output means (such as, a keyboard, a speaker, microphone, Light Emitting Diodes etc.) to communicate with the individuals (such as, the practitioner **110** and the patient) in the workspace **105**. In some examples, the graphical user interface may be a mobile application or a web application associated with the system **200** and the workspace **105** in which the system **200** is employed.

FIG. **6** illustrates an exemplary method **600** for protecting the workspace **105** from the airborne contaminants **120**. Initially, at Operation **602**, the processor **235** receives the sensing data associated with the workspace **105** captured by the at least one sensing capturing unit **205** positioned in the workspace **105**. Further, at Operation **604**, the processor **235** determines presence of the at least one source **130** of transmission of the airborne contaminants **120** in the workspace **105** based on the received sensing data, such as by using machine vision techniques now known or future developed.

Further, at Operation **606**, the processor **235** configures the capture zone **135** within the workspace **105** based on the determined at least one source **130** of transmission of the airborne contaminants **120** at Operation **606**. In some

embodiments, the processor **235** adjusts the capture zone **135** based on the operating state of one or more devices operable within the workspace **105** and/or the determined distribution pattern of the airborne contaminants **120** within the workspace **105**. In an embodiment, the processor **235** first detects the presence of the one or more devices operable within the workspace **105** and determines the operating state of each of the detected one or more devices. The processor **235** then adjusts the configured capture zone **135** based on the determined operating state of each of the one or more devices operable within the workspace **105**. Further, in another embodiment, the sensor unit **225** positioned within the workspace **105** detects the presence of the airborne contaminants **120"** in the workspace **105** and transmits the data associated with the detected presence of the airborne contaminants **120"** to the processor **235**. The processor **235** then determines the distribution pattern of the airborne contaminants **120"** in the workspace **105** based on the detected presence of the airborne contaminants **120"**. The processor **235** then further adjusts the configured capture zone **135** based on the determined distribution pattern of the airborne contaminants **120"** within the workspace **105**.

Further, at Operation **608**, the processor **235** controls the air transmission unit **210** to direct the unidirectional flow of air **140**, **140'**, **140"** over the capture zone **135**, **135'**, **135"** thereby directing movement of the airborne contaminants **120**, **120'**, **120"** in the capture zone **135**, **135'**, **135"**. In some embodiments, the processor **235** determines the intensity of the unidirectional flow of air **140**, **140'**, **140"** based at least on one of the determined operating state of the one or more devices or the determined distribution pattern of the airborne contaminants **120"** present within the workspace **105** and controls the air transmission unit **210** to direct the unidirectional flow of air **140**, **140'**, **140"** with the determined intensity over the capture zone **135**, **135'**, **135"**. In some additional embodiments, the processor **235** also controls the air transmission unit **210** to disperse the disinfectant over the capture zone **135**, **135'**, **135"**.

At Operation **610**, the processor controls an air capturing unit **215** to capture the unidirectional flow of air **140**, **140'**, **140"**, along with the airborne contaminants **120**, **120'**, **120"** directed from the air transmission unit **210**. In some embodiments, the processor **235** also controls the air capturing unit **215** to store air samples from the captured flow of air **140**, **140'**, **140"**, along with the airborne contaminants **120**, **120'**, **120"** in the air storage container **224**.

In some embodiments, the processor **235** further controls the filter unit **230** to receive the unidirectional flow of air **140**, **140'**, **140"**, along with the airborne contaminants **120**, **120'**, **120"** captured by the air capturing unit **215** via the conduit **255**. The processor **235** then determines the type of the airborne contaminants **120**, **120'**, **120"** captured by the air capturing unit **215** using the filter unit **230**. The processor **235** further controls the filter unit **230** to disinfect the captured airborne contaminants **120**, **120'**, **120"** based on the determined type of airborne contaminants **120**, **120'**, **120"**.

In some embodiments, the processor **235** further detects the malfunctioning of one or more of the air transmission unit **210**, the air capturing unit **215**, and the filter unit **230** and generates the alert indicative of the detected malfunctioning using the input-output unit **220**. In some embodiments, the processor **235** also controls the operating state of each of the one or more devices operable within the workspace **105** when the processor **235** detects the malfunctioning of one or more of the air transmission unit, **210** the air capturing unit **215**, and the filter unit **230**.

The embodiments described herein provide an effective and reliable solution for protecting the workspace **105** from the airborne contaminants **120**, **120'**, **120"**. The system and method described herein utilizes machine vision that automatically identifies various sources **130** of the airborne contaminants **120**, **120'**, **120"** in the workspace **105**, thereby facilitating the air curtain to be formed automatically in close proximity to the sources **130** of the airborne contaminants **120**, **120'**, **120"**. Moreover, the capture zone **135**, **135'**, **135"** that are suspected to be infected with the airborne contaminants **120**, **120'**, **120"** in the workspace **105** are configured and continuously adjusted based on the operating profile **510** of the workspace **105** and the distribution pattern of the airborne contaminants in the workspace **105**. This ensures that all possible areas that are suspected to be infected with the airborne contaminants **120**, **120'**, **120"** are always included in the capture zone **135**, **135'**, **135"**. In addition, the adjustment of the operating parameters of the one or more nozzles **222**, based on the operating profile **510** of the workspace **105** and the distribution pattern of the airborne contaminants in the workspace **105**, ensures that all possible airborne contaminants **120**, **120'**, **120"** are successfully trapped along with the flow of air **140**, **140'**, **140"** generated by the air transmission unit **210** and captured by the air capturing unit **215**, thereby preventing airborne contaminants **120**, **120'**, **120"** emanating from the patient to enter facial area of the practitioner **110** in the workspace **105**. In some embodiments, when the practitioner **110** is determined to be the source **130** of the airborne contaminants, the system and method described herein may further prevent the airborne contaminants emanating from the practitioner **110** to enter the facial area of the patient in the workspace **105**. This ensures that the individuals present in the workspace **105**, as well as the individuals that would use the workspace **105** in future are always safe and protected from the airborne contaminants. Moreover, the system and method described herein does not require the workers to wear any additional PPEs or garments, thereby allowing the workers to work with greater DoF.

Further, the use of machine vision and machine learning algorithms elevates the effectiveness and reliability of the system by adding a layer of intelligence that adjusts the capture zone **135**, **135'**, **135"** and the flow of air **140**, **140'**, **140"** based on a current functional environment (for example, the distribution pattern of the airborne contaminants **120**, **120'**, **120"**) of the workspace **105**. This ensures that the safe working environment is free from any airborne contaminants **120**, **120'**, **120"** and the required industry standards for a safe working environment are maintained at all times. Further, this adaptability and configurability make the benefits of this system and method extensible to various environments and various operating profiles applicable in the workspace **105**.

Moreover, the integration of the system **200** with the specific operations' environment of the workspace **105** offers immediate additional benefits to optimize and improve the performance of the workspace environment **100**. For example, when the system **200** is integrated with the chair **150**, the system **200** harmonizes and regulates the operation of the ancillary one or more devices (for example: ultrasonic scalers, dental handpieces, air-water-syringes, air guns, dental drills, etc.) to further assure that the power and pressure of the ancillary one or more devices conform to the best and safest profiles to limit/manage spillover outside of the capture zone **135**, **135' 135"**.

In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art

appreciates that various modifications and changes may be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

Moreover, in this document, relational terms such as first and second, top and bottom, front and rear, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by "comprises . . . a", "has . . . a", "includes . . . a", "contains . . . a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially", "essentially", "approximately", "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

It will be appreciated that some embodiments may be comprised of one or more generic or specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

Moreover, an embodiment may be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it may be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

We claim:

1. A system for protecting a workspace from airborne contaminants, the system comprising:

at least one camera positioned within the workspace and adapted to capture a sensing data associated with the workspace;

an air transmission unit adapted to direct a unidirectional flow of air;

an air capturing unit adapted to receive the unidirectional flow of air directed from the air transmission unit;

one or more devices configured to operate within the workspace;

a memory configured to:

store operating profiles associated with each of the one or more devices, wherein the operating profiles comprise an operating state of each of the one or more devices; and

store a positional information of each associated capture zone for each operating profile; and

a processor operatively coupled to the at least one camera, the air transmission unit, the air capturing unit, and the one or more devices, and the memory, the processor being configured to:

receive the sensing data associated with the workspace from the at least one camera;

determine presence of at least one source of transmission of the airborne contaminants in the workspace based on the received sensing data;

define the positional information of a capture zone within the workspace based on the determined at least one source of transmission of the airborne contaminants, the capture zone being an area suspected to be infected with the airborne contaminants transmitted from the determined at least one source of transmission of the airborne contaminants in the workspace;

determine an operating state of each of the one or more devices;

compare the operating state of each of the one or more devices to the stored operational profiles in the memory to determine the current operational profile;

change the positional information of the capture zone based on the stored positional information of each associated capture zone for the current operating profile;

determine the operating state of each of the one or more devices in the workspace;

control the air transmission unit to direct the unidirectional flow of air over the capture zone, thereby directing movement of the airborne contaminants in the capture zone; and

control the air capturing unit to capture the unidirectional flow of air, along with the airborne contaminants, directed from the air transmission unit.

2. The system according to claim **1**, further comprising:

at least one sensor positioned within the workspace and operatively coupled to the processor, wherein the at least one sensor is configured to detect presence and a physical area comprising positional information of the airborne contaminants in the workspace, and wherein the processor is further configured to:

determine, based on the detected presence and the area of the airborne contaminants, that the area is outside the positional information of the capture zone; and

change the positional information of the capture zone to include the area with the airborne contaminants outside the positional information of the capture zone; and

store the changed positional information in the memory.

3. The system according to claim **2**, wherein the at least one sensor includes one or more of a thermal sensor, a vapor sensor, a chemical sensor, a visual sensor, and a biological sensor.

4. The system according to claim **1**, wherein the air transmission unit comprises one or more nozzles controlled by an air nozzle controller,

wherein the memory is further configured to store data comprising operating parameters of the one or more nozzles corresponding to the operating state of the one or more devices, wherein the operating parameters comprise at least one of an angle, a height and an intensity at which the one or more nozzles operate to direct the unidirectional flow of air over the capture zone based on the positional information of the capture zone;

wherein the processor is further configured to:

determine the operating parameters of the one or more nozzles based on the data stored in memory; and

control the air nozzle controller to adjust the one or more nozzles based on the determined operating parameters.

5. The system according to claim **1**, wherein the processor is further configured to control the air transmission unit to disperse disinfectant over the capture zone.

6. The system according to claim **1**, further comprising:

a filter unit operatively coupled to the processor, wherein the filter unit is configured to receive the unidirectional flow of air along with the airborne contaminants captured by the air capturing unit, and

wherein the processor is further configured to

control the filter unit to disinfect the captured airborne contaminants using one or more disinfectants from a group including chemical disinfectants, ultraviolet lights, and thermal disinfection.

7. The system according to claim **1**, wherein the air capturing unit includes an air storage container, and wherein the processor is further configured to control the air capturing unit to store air samples from the captured flow of air along with the airborne contaminants in the air storage container.

8. The system according to claim **6**, further comprising:

an input-output unit positioned within the workspace and operatively coupled to the processor,

wherein the processor is further configured to:

detect a malfunctioning of one or more of the air transmission unit, the air capturing unit, and the filter unit, and

generate, using the input-output unit, an alert indicative of the detected malfunctioning.

9. The system according to claim **8**, wherein the processor is further configured to:

control an operating state of the one or more devices when the processor detects the malfunctioning of one or more of the air transmission unit, the air capturing unit, and the filter unit.

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