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MULTI-SENSORY STIMULATION SYSTEM AND ASSEMBLY

Technical Field

5 The present invention relates, in general terms, to a multi-sensory stimulation system. The present invention also relates to a multi-sensory stimulation assembly incorporating such a system.

Background

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Recent breakthroughs in audio-visual technologies have enabled interactive virtual experiences such as games, simulations and 360° videos (with spatial audio) via desktop and Virtual Reality (VR) solutions. These virtual-world experiences primarily engage our sense of vision and audition; however, we
15 experience the real-world through a range of senses. Experiencing these virtual-worlds through multiple sensory modalities augments both our presence within a scenario as well as our reaction to it (gameplay mechanic).

One issue in providing multiple sensory modalities is the directionality of those
20 modalities when compared with the position of the user, and the area coverage of those modalities – e.g. the feeling of radiant heat on the skin is not localised to a particular point. In such systems it makes sense to position a static body – e.g. a heater – at some distance from the user. But this doesn't make sense when a user is traversing an area where different virtual heat sources are
25 located at different positions relative to the user.

It would be desirable to provide a multi-stimulation system in which at least one of the above-described problems has been overcome or ameliorated, or at least to provide a useful alternative to systems of the art.

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Summary

Disclosed herein is a multi-sensory stimulation system comprising:

an inlet for receiving a flow of liquid or gas;

5 a conditioning system for drawing the flow of at least one of liquid, gas and electricity (the **Flow**) through the inlet, the conditioning system comprising two or more conditioning modules for conditioning the Flow according to a respectively different sensory modality; and

an outlet for delivering the conditioned Flow.

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The multi-sensory stimulation system may comprise a control module, the control module:

receiving event information from an environment simulation engine, the event information specifying particular sensory stimuli in a virtual environment

15 comprising the user; and

activating at least one said conditioning module according to the event information.

The inlet may comprise two or more inlet apertures, and the Flow comprises an
20 independent flow to each of a corresponding two or more of said conditioning modules. The outlet may comprise two or more outlet apertures, and the Flow comprises an independent outflow for each outlet aperture.

The event information may comprise duration information specifying a duration
25 of activation of the at least one conditioning module.

The event information may comprise intensity information specifying an intensity of activation of the at least one conditioning module. The intensity information may comprise a time-varying intensity profile, and the intensity of
30 activation of the at least one conditioning module varies over time according to the intensity profile.

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The event information comprises location information.

At least one conditioning module may be an olfactory stimulation module comprising at least one aroma chamber containing a scent, each aroma chamber being configured to deliver the respective scent into the Flow and the conditioned Flow thereby comprising a scented Flow. The multi-sensory stimulation system may comprise a plurality of said aroma chambers each of which contains a different scent. The event information in such cases may comprise a scent profile, the control module being configured to activate two or more aroma chambers according to one or more scents specified in the scent profile.

At least one conditioning module may be a thermal stimulation module comprising a temperature conditioning (e.g. heating and/or cooling) element configured to control a temperature of the Flow and the conditioned Flow thereby comprising a temperature controlled Flow.

At least one conditioning module may be a somatosensory module for changing a speed of the Flow to thereby apply a non-contact haptic stimulus to the user upon delivery through the outlet.

The event information may further comprise direction or orientation information specifying a direction along which to apply the condition Flow.

The multi-sensory stimulation system may comprise a mount portion for connection to a head mounted display to secure the system in relation to a head of the user.

The multi-sensory stimulation system may further comprise a gustatory stimulator shaped to be received in a mouth of the user, the gustatory stimulator comprising at least one electrical stimulation device for delivering at

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least one of electrical stimulation and thermal stimulation to a tongue of the user.

Also disclosed herein is a wearable multi-sensory stimulation assembly
5 comprising:

a wearable member configured to be worn by a user; and

one or more multi-sensory stimulation systems as described above,
located on the member to enable directional stimulation of at least one sensory
system of the user when wearing the assembly.

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The wearable member may comprise a garment wearable on a chest of the user,
the assembly comprising a plurality of said multi-sensory stimulation systems
located around a collar of the garment.

15 The wearable system may further comprise a contact thermal stimulator
comprising one or more thermal elements located, in use, near skin of the user
to control a temperature of the skin – e.g. to heat or cool the skin in the vicinity
of the contact thermal stimulator. The wearable system may instead, or in
addition, further comprise a contact somatosensory stimulator comprising one
20 or more motorised units located, in use, near skin of the user to apply a force
to the skin, and/or one or more electrode patches for delivering electrical
stimulation to at least one muscle of the user. The event information may
further comprise orientation or direction information specifying a direction along
which the apply heating, cooling or force to the skin.

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The wearable member may comprise a head mounted display and at least one
said multi-sensory stimulation system is mounted on the head mounted display.
The wearable system may comprise a plurality of multi-sensory stimulation
systems mounted on the head mounted display.

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The wearable system may further comprise an auditory stimulator located on the head mounted display located to deliver an audial signal to the auditory stimulator.

5 Advantageously, embodiments of the invention provide controlled multi-modal (i.e. multiple human senses) stimulation of a plurality (more than one) of human senses that is synchronized with the virtual-world (e.g. games, simulations and broadcasts on desktop and Virtual Reality (VR) platforms). This enables the virtual-world to be experienced through multiple sensory modalities thereby
10 augmenting a sense of presence/immersion within a scenario and the user's reaction to it (gameplay mechanic).

Some embodiments provide a plug-and-play design that allows for configuration of simulation modules (number, type and location of modules) physically,
15 and/or event information (including within its scope stimuli parameters such as intensity and duration, where context allows) digitally. The system and assembly can therefor adapt to complement the nature of the virtual-world, and/or cater to the subjectivity of the human senses – e.g. allow the stimuli parameters to be scaled or controlled such as by adjusting the volume of a
20 speaker or the dosage of an aroma produced by an olfactory stimulation device. Advantageously, embodiments of the present invention use an operating system independent Application Programming Interface (API). Enables integration of multi-sensory stimuli into existing and new desktop and VR applications/systems.

25 Some embodiments include one or more olfactory simulators. Such stimulators deliver scents to a user (e.g. smell of smoke if something is burning in the virtual-world). Stimulates the user's sense of olfaction in the virtual-world – e.g. relative to the virtual reality they are viewing.

30 Some embodiments include one or more thermosensory simulators. Such stimulators deliver to a user non-contact thermal stimuli (e.g. gush of hot air

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from a blast in the virtual-world), and/or contact thermal stimuli (e.g. cooling user's body if it is winter in the virtual-world). This stimulates the user's sense of thermoception in the virtual-world.

5 Some embodiments include one or more somatosensory simulators. Such stimulators deliver to a user non-contact haptic stimuli (e.g. wind mimicking the direction and intensity as in the virtual-world), and/or contact haptic stimuli (e.g. vibration in-case of use of a heavy-duty machine in the virtual-world). This stimulates the user's sense of somatoception in the virtual-world.

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Some embodiments include one or more gustatory simulators. Such stimulators deliver electrical taste stimulation to a user's tongue (e.g. tasting a lollipop in the virtual-world). Stimulates the user's sense of gustation in the virtual-world.

15 Some embodiments include one or more auditory simulators. Such stimulators deliver directional sound to a user. Stimulates the user's sense of audition in the virtual-world.

Brief description of the drawings

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Embodiments of the present invention will now be described, by way of non-limiting example, with reference to the drawings in which:

Figure 1 is an overview of a system architecture for a multi-sensory augmented
25 virtuality (MAV) suit in accordance with present teachings;

Figure 2 is a schematic layout of a multi-sensory stimulation module for, for example, face mounting comprising thermal, somatosensory and olfactory stimulation modules;

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Figure 3 is an illustrative embodiment of a control module showing the primary printed circuit board (PCB – Figure 3a), a metal oxide silicon field effect

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transistor (MOS FBT) PCB breakout (Figure 3b), and a universal serial bus C (USB-C) connector PCB Breakout; and

Figure 4 is a photo of a MAV Suit for use in a gaming context; and

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Detailed description

Described herein is a MAV suit - a wearable suit that engages user's senses such as olfactory, somatosensory and thermosensory senses in the virtual-world. In some embodiments, the suit communicates with desktop and virtual reality (VR) platforms to dynamically control and synchronize multi-sensory stimuli. By delivering olfactory, wind, tactile and contact and non-contact thermal stimuli using the system disclosed herein, traditional audio-visual technologies achieve enhanced sensory engagement and merge real-world essentials into the virtual-world. In this context, "essentials" are considered to be perceivable senses such as thermosensation, olfaction, gustation, and somatosensation for which stimulation devices disclosed herein have been developed, and others such as vision and audition.

20 Such a suit will employ a multi-sensory stimulation system such as system 100 shown in Figure 1. The system 100 includes an inlet 102 for receiving a flow of liquid or gas, a conditioning system 104 comprising two or more conditioning modules (each being herein referred to as sensory simulation/stimulation module - 106), and an outlet 108.

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Each inlet 102 provides an opening or connection through which a flow is drawn into the system 100. The conditioning system 104 then draws the flow through the inlet or inlets 102. The conditioning system 104 may comprise a fan to draw gas such as ambient air into the system 100 through one or more of the inlets 102. The conditioning system 104 may instead, or in addition, comprise a pump to draw liquid such as water into the system 100 through one or more of the inlets 102. In some embodiments, such as those in which one of the sensory

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simulation modules 106 provides a thermosensory stimulus (e.g. heating or cooling), provides direct muscle stimulus, or stimulates electrodes – e.g. in a gustatory stimulation module – one or more inlets 102 may be a connection to a power source and the flow may therefore comprise power or electricity, and
5 the conditioning system 104 therefore comprises a load for drawing the flow through the connection.

There may be a single inlet 102 through which the flow is drawn for all of the sensory simulation modules 106. In other embodiments, a single inlet 102 may
10 service (i.e. enable flow to be provided to) multiple sensory simulation modules 106. Where a multi-sensory stimulation system includes a plurality of inlet apertures, these inlet apertures may be inlet apertures to specific ones of the conditioning modules. For example, a single externally accessible aperture may lead to an internal conduit that bifurcates at two separate (i.e. independent)
15 inlets to separate a flow of liquid or air into two separate/independent flows. Alternatively, the two separate/independent inlets may both be externally facing or externally accessible. In other embodiments, a single conditioning module may be served by more than one inlet aperture. It will be appreciated that other combinations of inlets may be provided, such as a single inlet 102 through which
20 gas is drawn for feeding all sensory simulation modules 106 that rely on a feed of gas, a separate inlet 102 may be provided through which liquid is drawn for feeding all sensory simulation modules 106 that rely on a feed of liquid, and a single connection 102 may be provided for supplying power to all sensory simulation modules 106 that require such a power source.

25 Similarly, the outlet 108 may comprise a separate outlet for each sensory simulation module 106, where single outlet for all sensory simulation modules 106, or any combination thereof. Where there are multiple outlets, the flow through the system 100 may become an independent outflow for each aperture.
30 This will enable a single incoming flow to become multiple outgoing flows for example, there may be drawn into the system and heated or dosed with aroma

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and the heated or dosed air may then be delivered to multiple locations on a user's body (which in present circumstances can include their head).

5 The conditioning modules or sensory simulation module 106 condition the flow according to a respectively different sensory modality. Accordingly, at least two sensory stimuli can be concurrently delivered to the user. Any combination of sensory simulation modules 106 may be used to suit the particular senses desired to be stimulated.

10 Figure 2 provides a schematic layout of a multi-sensory simulation module 200 configured mounting on or near the face of a user. The simulation module 200 has a variety of sensory simulation modules including a thermal simulation module 202, somatosensory simulation module 204 and olfactory simulation module 206.

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The olfactory stimulation module 206 includes an aroma chamber 208. In some cases there may be multiple aroma chambers (or more than one olfactory stimulation module 206) such as when multiple different scents (e.g. essential oils) are to be delivered or combined, where the same scent is to be delivered
20 at multiple locations on the user's body, or where significant variability in the intensity of the scent is required. Each aroma chamber thus contains a scent and is configured to deliver the scent into a flow of air or gas to scent that flow.

In the present case, the aroma chamber 208 is adapted to retain a cartridge
25 containing the aroma. Aroma is dispensed from the cartridge into the flow to condition or saturate the flow with scent. In other embodiments, the aroma chamber 208 includes a liquid reservoir with an atomiser or nozzle in fluid communication therewith, the atomiser or nozzle being activated to deliver a dose of aroma from within the aroma chamber 208 to an airflow to be delivered
30 to the user.

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The olfactory stimulation module 206 also includes an air-pump or fan 210 and inlet 212, the fan 210 drawing the flow of air through the inlet 212 for dosing with aroma. The olfactory stimulation module 206 then delivers the scented flow through an outlet 214 to the user, using a pneumatic actuator which may be
5 fan 210 or other air-pump device.

In one embodiment, the fan 210 is a separate 12V fan (i.e. independent of any other fans or blowers in system 200) for channelling air through the aroma chamber 208 (saturated with the scent from a loaded cartridge) into a tube
10 delivering olfactory stimuli to the user. The stimuli may be intensity controlled via pulse width modulation (PWM) and MOSFET based digital switch circuitry. In this manner, and aroma delivered by olfactory stimulation module 206 is not degraded by the heating element 216 prior to being delivered to the user. In other embodiments, the olfactory stimulation module 206 may deliver the
15 scented flow into another module, for example the thermosensory simulation module 202, so that the flow directed onto the user stimulates multiple human senses.

The thermal simulation module 202 includes one or more temperature
20 conditioning elements, presently embodied by heating element 216 that is configured to heat the flow. The heating element 216 may be a Peltier, positive temperature coefficient (PTC) heating element, wire mesh or other construct through which a current is passed to heat the mesh or construct and thereby heat a flow passing through the mesh or construct through convection. It will
25 be understood that one or more heating elements may be replaced by a cooling element to condition the flow by cooling, or one or more elements that collectively provide selective heating and cooling of the flow. In any case, the effect of a temperature conditioning element is the production of a temperature controlled flow.

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The heating element 216 is suspended in a temperature control chamber, presently embodied by heating chamber 218. Air is drawn into the heating

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chamber 218 through an inlet 220, provided on a side of the system 200. The heated flow is then delivered from the heating chamber to the user through outlet 222. The fan used to push the air through chamber 218 may be a 12V blower that sucks in air and pushes it through the heating chamber 218. The heating element 216 itself may be intensity controlled via pulse width modulation (PWM) and MOSFET based digital switch circuitry as discussed with reference to Figure 3. The heating element 216 may be a 24V/2A PTC heating element with a surface temperature of 220 °C (power toggled digitally via an opto-isolated relay) that heats up the air in the flow that is subsequently channelled to deliver a combination of thermosensory and somatosensory stimuli the user as discussed below. Within the module, this heating element is suspended using a structure made of Mica sheet to thermally isolate it from the plastic enclosure (softening point greater than 230 °C) thereby ensuring safety from direct contact heating.

The thermosensory simulation module 202 may deliver non-contact thermal stimuli when clubbed or combined with a pneumatic somatosensory simulator module (i.e. heated or cooled air) as discussed below, or may deliver direct contact thermal stimuli through the use of, for example, a heating and/or cooling pad placed against the user's skin.

The somatosensory stimulation module 204 controls the application to a user of a non-contact haptic stimulus. The non-contact haptic stimulus presently comprises a flow of air. The somatosensory module 204 changes the speed of the flow to thereby change the amount of pressure applied to a particular location on the user's body, the change in pressure providing a non-contact haptic stimulus. This is achieved using a blower or fan 224 that draws air into an inlet 226. The speed of the blower or fan 224 is controlled by control module 210, thereby controlling the speed of the flow passing through the blower or fan 224.

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The flow from the somatosensory stimulation module 204 may be delivered to the user through a separate outlet but, in the present case, is delivered through the heating chamber 218 and corresponding outlet 222. Accordingly, the same blower or fan 224 may be used to drive air through the heating chamber 218
5 for heating by the thermosensory stimulation module 202.

In other embodiments, the somatosensory simulation module may include one or more elements that are driven against the body of the user to deliver a touch sensation. For example, a small pad on the end of a solenoid driven piston, may
10 be driven against the skin of the user by the control module 110 by activating the solenoid. In other embodiments, the somatosensory system uses vibration, or servo displacement, depending on the desired type of contact haptic stimuli and actuators (such as pneumatic pumps, fans, ultrasound) depending on the desired type of non-contact haptic stimuli.

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In yet further embodiments, the somatosensory stimulation module delivers a flow of electricity to the wearer, to stimulate muscle movement (e.g. contraction). That muscle movement provides haptic feedback to the wearer.

20 In addition to the modules set out above, the present system 200 comprises a gustatory stimulator 228. The gustatory stimulator 228 is shaped to be received in a mouth of the user – presently in the form of a tongue depressor. The gustatory simulator module 228 utilizes electrical stimulation devices (e.g. electrodes 230) to deliver a flow of controlled electrical and/or thermal stimuli
25 to the user's tongue in-order to elicit a perception of "digital and/or thermal taste". Where electrical stimulation is provided, the electrical stimulation devices 230 may each be located at a position to stimulate a particular sensory response of the users tongue – in this regard, electrode stimulation of a tongue at different locations will stimulate different taste responses such as a bitter
30 taste, sweet taste or sour taste. Thus the electrical stimulation devices 230 may be located on the gustatory stimulator 228 such that, when positioned in a

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user's mouth, particular taste responses can be stimulated in a controlled manner by controlling respective ones of the electrical stimulation devices 230.

5 A device similar to, or the same as, the gustatory stimulator 228 may be provided in a patch, electrode or electrode array positionable on or near the skin of the wearer. A flow, comprising an electric current, may be applied to the patch to directly stimulate a muscle of the wearer.

As will be appreciated in view of present teachings, the system 200 may further
10 include an auditory simulator module (not shown) comprising one or more speakers, for example an array of speakers, that are controlled to deliver sound. Where more than one speaker is provided, the sound may be directional. Auditory simulator modules and their operation are known and need not be described herein in detail.

15 The various stimulation modules 202, 204, 206 and 228 may connect to a control module (see Figure 3) in any desired manner – e.g. through wireless connection to a remote control module, or through hardwired connection such as a USB-C connection 238. The connection 238 provides a single high-power
20 cable originating from the USB-C connector of the multi-sensory simulation module 200 and linking the actuators of modules 202, 204, 206 and 228 to the control module. The control module can communicate with an application (e.g. desktop and/or VR application) running elsewhere, to synchronise and deliver control multi-sensory stimuli to a user who may be already receiving video
25 and/or auditory VR feed.

The system 200 is designed to be mounted onto a wearable body such as a helmet or headband. To that end, the system 200 comprises a unitary housing
232 in which the various sensory simulation modules are contained, and a
30 mounting structure 234 for connecting the system 200 to the wearable body. The housing 232 and mounting structure 234 are connected by a movable

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connection 236 presently embodied by a hinge. The movable connection enables the position of the outlets 214, 222 to be adjusted for each user or application.

The above system 200 may be incorporated into a MAV suit, which is a
5 "wearable" or "wearable body" that, when operated, engages user's senses such as olfaction, somatosensation and thermoception in the virtual-world. This may be done with reference to a virtual environment or scene presented to the user, e.g. in VR goggles. The present mounting structure or mount portion 234 is configured to mount the multi-sensory simulation module 200 on a head-
10 mounted display (HMD), thereby securing the system 200 in relation to the head of the user. This enables the system to, for example, focus on the user's face or neck as desired. The system 200 may have power consumption and other requirements tailored to suit a particular application.

15 Figure 3 shows an illustrative embodiment of the control module 300, for use in a MAV suit 400 as shown in Figure 4, in accordance with present teachings. The control module 300 receives event information from an environment simulation engine (e.g. desktop/VR application 118). The environment simulation engine specifies event information from which the control module 300 can determine
20 which sensory simulation modules to activate and other parameters – e.g. intensity and duration of stimulus.

The control module 300 is a microprocessor-based system having signal conditioning circuitry 302 (e.g. Transistor-Transistor Logic level shifting), power
25 supply regulation circuitry (e.g. 3.3V, 5V, 9V, 12V, 24V compliant, as needed for any particular application), control circuitry (e.g. MOSFETs and relay based), communication modules (e.g. such as Bluetooth, Wi-Fi, USB), and peripheral communication interfaces (e.g. I2C, UART, SPI). The peripheral communication interfaces enable control of actuators of the sensory simulation modules as well
30 as sensors (such as a temperature sensor – see sensor 122 of Figure 1). Each sensor provides feedback to the control module from which it can determine adjustments to control signals for the various sensory simulation modules,

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and/or from which it can inform the environment simulation engine of an event – e.g. that the user has changed viewing direction or as otherwise responded to a stimulus. The microprocessor of the control module 300 establishes bidirectional handshake communication with a desktop/VR application to receive
5 commands, decode and generate appropriate control signals for the peripherals, and subsequently acknowledge their execution.

The control module 300 includes an I/O interface for each sensory simulation module. In the MAV suit 400 there are five sensory simulation modules.
10 Accordingly, the control module 300 includes five interfaces 302, 304, 306, 308 and 310.

The control module 300 receives event information from the environment simulation engine as discussed above. The event information specifies particular
15 sensory stimuli in a virtual environment comprising the user – for example, the event information may specify a particular directional thermal stimulus should be applied where the user is near a source of heat in the virtual environment. The control module 300 then activates one or more of the conditioning modules or sensory stimulation modules according to the event information, by the
20 corresponding interface 302, 304, 306, 308 and 310.

The control module may be designed to suit a particular application – a custom designed primary PCB that serves as a breakout for connecting all the components (refer to Figure 3A). These components may include a
25 microcontroller, opto-isolated relay, custom designed N-Type MOSFET PCBs (refer, for example, to MOSFETs B/O 312 in Figure 3A, and Figure 3B), USB-C connector PCBs (refer, for example, to Figure 3C) and a power terminal connector. The module 300 also includes a relay 314 for relaying signals such as, for example, control signals between devices (e.g. where more than one
30 control module is provided), and a power terminal 316 for receiving power from a power source (e.g. battery – not shown).

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- In the suit 400, a Bluetooth low energy (BLE)-enabled microcontroller (Atmega328 + TI CC2540) is employed for bi-directional communication with the VR environment via a micro USB cable or wirelessly through Bluetooth. On receiving commands (event information) based on the events in the game, the
- 5 microcontroller decodes the commands, generates signals to control the sensory stimulation modules in real-time - the parameters (intensity and duration) of the thermosensory, somatosensory and olfactory simulation for delivery by the sensory stimulation modules – and acknowledges their execution.
- 10 Key design considerations of this control module 300 include: USB-C based connection (between control and Multi-sensory Simulation Module) to support high-power transmission, fast data transmission/control and the orientation reversibility. Orientation reversibility ensures no damage due to pin mismatch; optimised PCB trace width and route to support high-power (over 100W is drawn
- 15 by the Multi-sensory Simulation Modules) and reduce noise; opto-isolated relay and power MOSFET based circuits to power (on/off) the heating elements and fans/blowers; PWM to ensure safety and control intensity of the heating elements and fans/blowers; and primary PCB designed as a breakout board to enable plug-and-play/replacement of individual components.
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- The event information received by the control module 300 from the environment simulation engine can result in a simple on of activation of a sensory stimulation module. Alternatively, the event information may include duration information specifying a duration of activation of the at least one conditioning module, or
- 25 intensity information specifying an intensity of activation of the at least one conditioning module. For example, a flow of heated air may be applied to a user for two seconds at a temperature of 35°, or for a different period of time at a different temperature. In some cases, the intensity information includes a time-varying intensity profile, and the intensity of activation of the at least one
- 30 conditioning module varies over time according to the intensity profile. For example, the temperature of the flow of heated air may be varied over time according to a time-varying intensity profile. Similarly, the event information

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may contain a scent profile, the control module being configured to activate two or more aroma chambers according to one or more scents specified in the scent profile. This would enable the olfactory simulation system to produce a particular scent formed from various combined scents. The scent profile may
5 also apply to a single aroma chamber, and result in variations of concentration of one or more scents over time according to the scent profile.

The event information can also include location information. This is particularly important when determining the sources of sensory stimulus appearing in the
10 virtual environment. For example, it may make sense only to direct and aromatic flow onto the user's face when the user is located in the vicinity of a flower. Similarly, event information may include direction or orientation information specifying a direction along which to apply the condition flow. For example, an simulation system may apply a lather volume for the speaker
15 located near one ear of a user when compared with the speaker located near the other ear, so the user knows the approximate location of the source of that audio in the virtual environment.

Figure 4 shows an MAV suit 400. Broadly speaking, the MAV suits described
20 herein are each a wearable multi-sensory stimulation assembly that includes a wearable member configured to be worn by a user, and one or more multi-sensory stimulation systems such as that described with reference to Figure 1 and 2. The multisensory stimulation systems are located on the wearable member to enable directional stimulation at least one sensory system of the
25 user when wearing the assembly.

The wearable member may be a single component such as a HMD or, as shown in Figure 4, may include a variety of wearable components. In particular, the wearable member includes a garment or vest 402 wearable on a chest of the
30 user. The vest 402 supports a plurality of multi-sensory stimulation systems around its collar 404. These stimulation systems include a thermal and somatosensory simulation system 406 on the right-hand side of the collar 404,

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and a similar system 408 on the left-hand side of the collar 404 (at the shoulders), the rear of the collar (not shown), the front 410 (anterior side – focussed on the upper thorax/throat) and back 412 (posterior side) of the vest 402.

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The thermal stimulators are contact thermal stimulators each comprising one or more thermal elements located, in use, near skin of the user to heat the skin. The somatosensory stimulators each include one or more motorised units also located, in use, near skin of the user to apply a force to the skin. The contacts
10 or motorised units need not be against the skin but may instead warm or apply pressure to the skin through one or more layers of material. In some embodiments, one or more of the somatosensory stimulators may include, in addition or as an alternative to the motorised units, one or more electrode patches for delivering electrical stimulation to at least one muscle of the user –
15 such a patch may be muscle stimulation system 422.

The wearable member also includes a HMD 414 with a multi-sensory stimulation system 416 mounted on the HMD 414 - in some embodiments, a plurality of stimulation systems may be provided on the HMD 414. The HMD 414 includes
20 audio and visual sensory stimulation systems known for a variety of pre-existing VR systems. The HMD 414 also interacts with a controller 418 with which the user interacts with the virtual environment. Notably, the sensory systems are typically systems by which the virtual environment acts on the user whereas the controller 418 enables the user to act on objects in the virtual environment.

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The multisensory stimulation system 416 provides thermosensory, somatosensory and olfactory stimulation functions and is located to deliver thermal, somatosensory and olfactory stimuli to the face of the user. A gustatory stimulation module may also be provided due to the proximity of system 416 to
30 the user's mouth, although the present embodiment does not include a gustatory stimulation module.

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The wearable member also includes a muscle stimulation system 422 positioned on or sufficiently near the skin of the wearer, such that a flow of electric current stimulates a response of the wearer – e.g. in muscle near the skin.

5 In use, the environment simulation engine will deliver event information to control module 420 located at the user's hip on the vest 402. As discussed above event information is used by the control model 420 to control the various stimulation modules. That control may enable directional sensing, such as heat coming from a particular side of the user's body, and to that extent the event
10 information may comprise orientation or direction information specifying the direction along which the stimulus – e.g. heat or force – is to be applied to the skin of the user. As used herein, stimulus applied 'to the skin' of the user or similar will be understood to mean direct-contact application as well as application of stimulus through one or more layers of material and, if context
15 permits, non-contact application of stimulus.

The MAV suit 400 of Figure 4 is simply one of a variety of assemblies or embodiments of a system for multisensory stimulation in accordance with present teachings. The MAV suit 400 can include or be paired with a VR HMD
20 gameplay and other purposes. In some games, such as Foxfire, heat (non-contact thermosensory), wind (non-contact somatosensory) and smell (olfactory) stimulators provide cues for the player to, for example, find and stop a target such as stopping a Foxfire from burning down a house. In addition to being embedded as a gameplay mechanic (e.g. burning smell to trace path
25 taken by the Foxfire / heat of a certain intensity and originating from a certain direction to distinguish the real Foxfire from its clones etc.), these sensory stimuli also create a more immersive VR environment. The vest, collar and the individual modules/components can be adjusted to a player's or user's form factor by providing straps, Velcro and a reversible USB-C based design.

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In-order to complement the nature of the virtual-world as well as to cater to the subjectivity of the human senses, the plug-and-play design of the MAV suit 400

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allows for physical configuration of simulation modules (number, type and location of modules) and digital control of stimuli parameters (intensity and duration). The API of the MAV suit 400 is operating system independent and enables it to readily be integrated with existing desktop and VR applications.

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In addition, the wearable member may include an HMD or vest as described above, and/or a shirt, hat, collar, pants, any other item worn around the neck or any other wearable member designed to position sensory stimulation systems such as that described with reference to Figure 1 at a desired location on the user's body. By providing multi-sensory stimulation as presently described, the system 100 and assembly 400 can increase both a user's sense of presence and their memory of a virtual environment.

As a result, the MAV suit 400 has a wide range of potential applications in fields including e-sports, interactive movies and new media, broadcasting, training simulations as well as rehabilitation. With the global eSports market growing at breakneck speeds, MAV Suit 400 can be integrated into the game mechanics as well as be employed to improve immersion – e.g. increase in intensity of cold wind on a user's face on speeding / skiing downhill in VR. The MAV Suit 400 will also augment current broadcasting practices into live multi-sensory broadcasting with 360° videos and spatial audio – e.g. remotely experience hiking with an individual via a live stream of synchronized ambient weather conditions, wind patterns, 360° views and sound. MAV Suit 400 may also be used as an alternative to existing training and simulation methods where-in it is dangerous, expensive or impractical to send trainees into real-world situations – e.g. firefighting.

It will be appreciated that many further modifications and permutations of various aspects of the described embodiments are possible. Accordingly, the described aspects are intended to embrace all such alterations, modifications, and variations that fall within the spirit and scope of the appended claims.

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Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer
5 or step or group of integers or steps.

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that
10 prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.