US 20150189223A1

(19) **United States**

(12) **Patent Application Publication**

LEVESQUE et al.

(10) **Pub. No.: US 2015/0189223 A1**

(43) **Pub. Date: Jul. 2, 2015**

(54) **SYSTEMS AND METHODS FOR RECORDING AND PLAYING BACK POINT-OF-VIEW VIDEOS WITH HAPTIC CONTENT**

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(21) Appl. No.: **14/585,752**

(22) Filed: **Dec. 30, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/922,648, filed on Dec. 31, 2013.

Publication Classification

(51) **Int. Cl.**

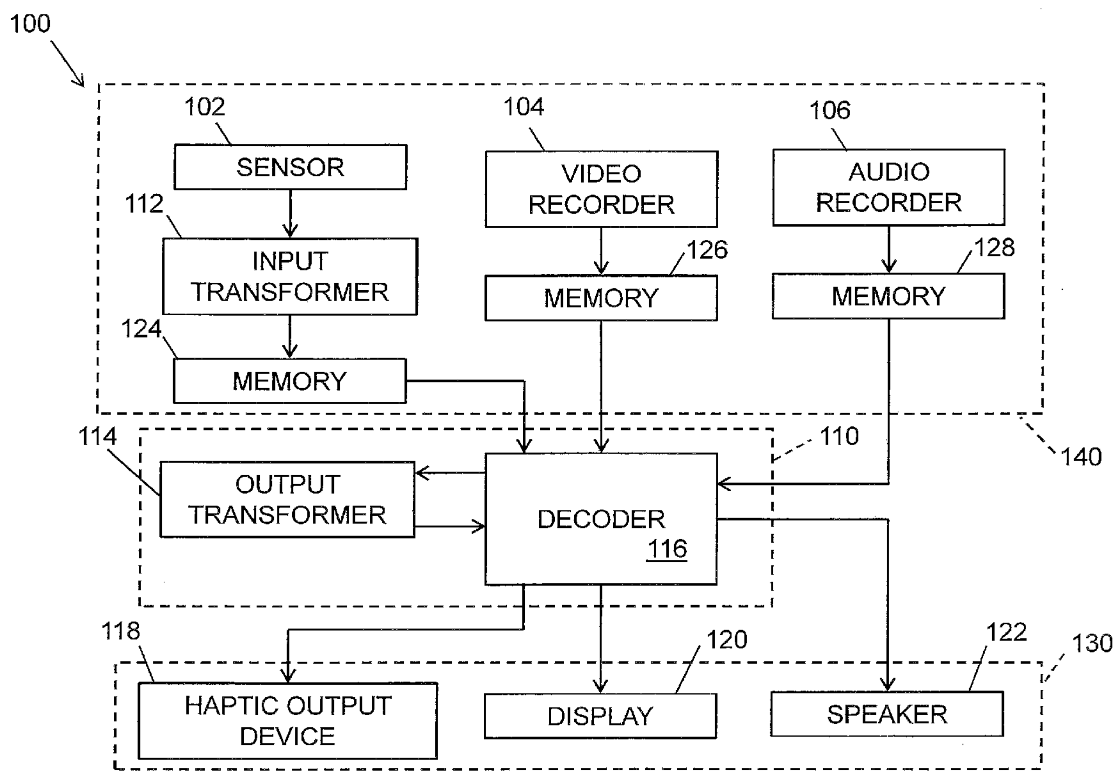
H04N 5/93	(2006.01)
G09B 5/02	(2006.01)
G08B 6/00	(2006.01)
H04N 5/77	(2006.01)
H04N 5/74	(2006.01)

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

CPC ***H04N 5/9305*** (2013.01); ***H04N 5/77*** (2013.01); ***H04N 5/7491*** (2013.01); ***G08B 6/00*** (2013.01); ***G09B 5/02*** (2013.01)

(57) **ABSTRACT**

A system includes a video recorder configured to record a point-of-view video of an event, a sensor configured to sense vibrations associated with the event, a processor configured to synchronize the recorded point-of-view video and the sensed vibrations, and a playback device that includes a display and a haptic output device. The playback device is configured to play back the synchronized point-of-view video and vibrations, and the haptic output device is configured to generate haptic effects based on the vibrations.



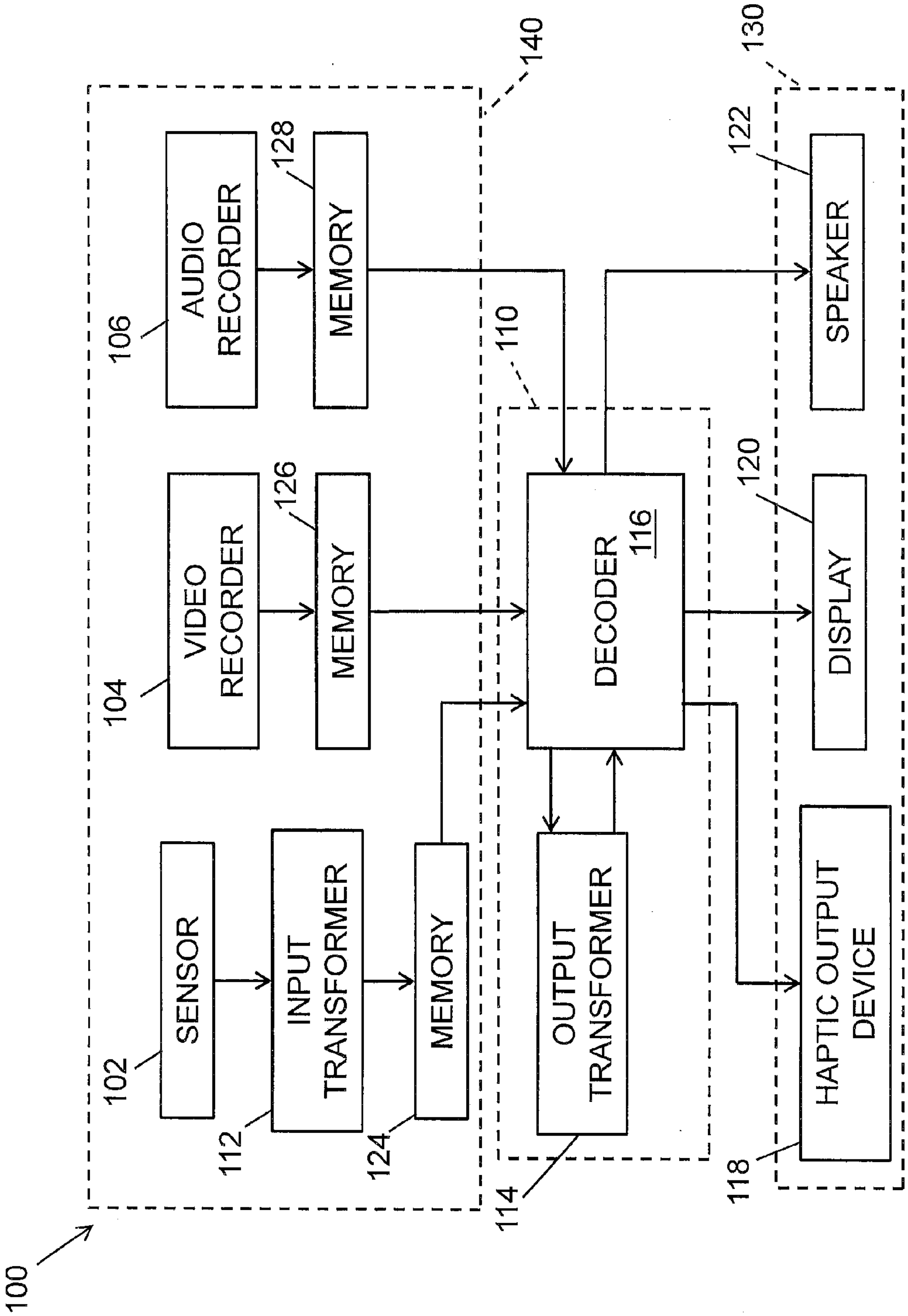

100
102
SENSOR
112
INPUT TRANSFORMER
124
MEMORY
104
VIDEO RECORDER
126
MEMORY
106
AUDIO RECORDER
128
MEMORY
140
110
DECODER
116
114
OUTPUT TRANSFORMER
130
122
SPEAKER
120
DISPLAY
118
HAPTIC OUTPUT DEVICE

FIG. 1

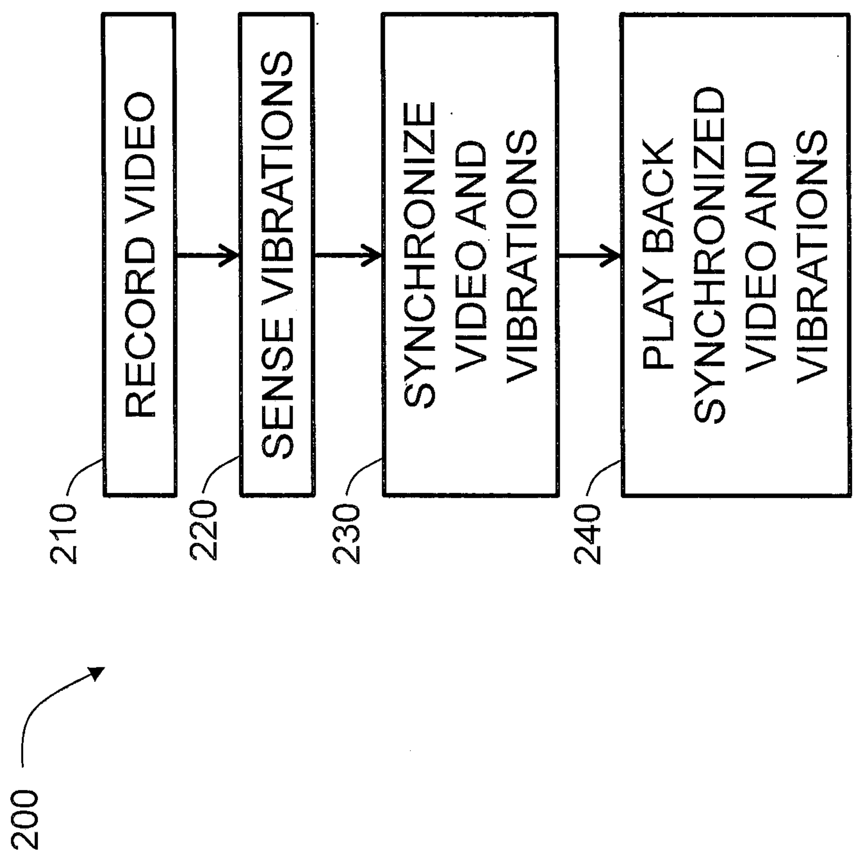

200
210
RECORD VIDEO
220
SENSE VIBRATIONS
230
SYNCHRONIZE VIDEO AND VIBRATIONS
240
PLAY BACK SYNCHRONIZED VIDEO AND VIBRATIONS

FIG. 2

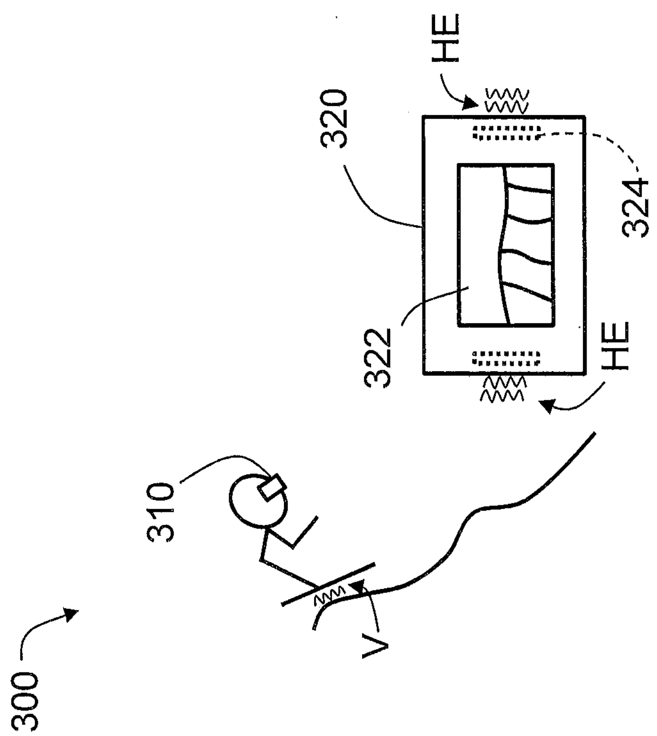


FIG. 3

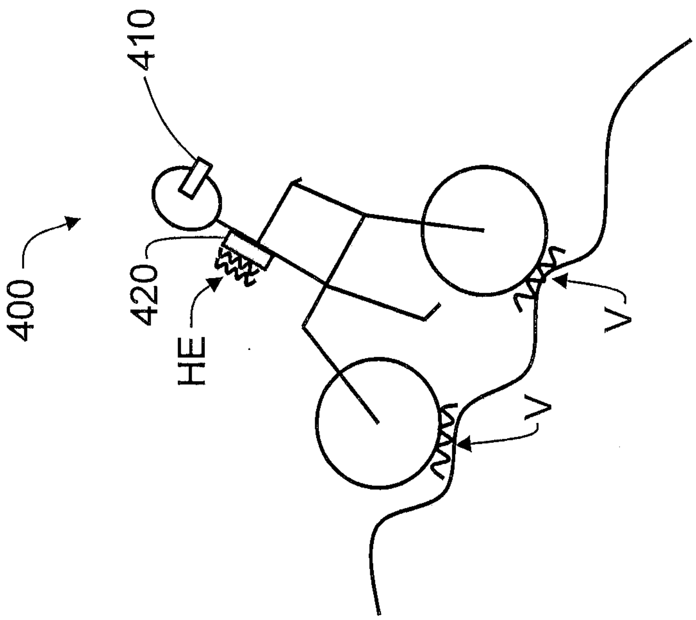


FIG. 4

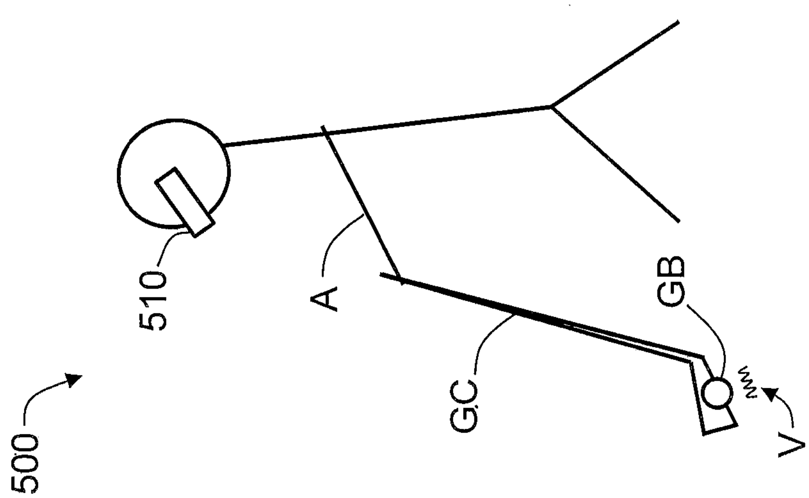


FIG. 5A

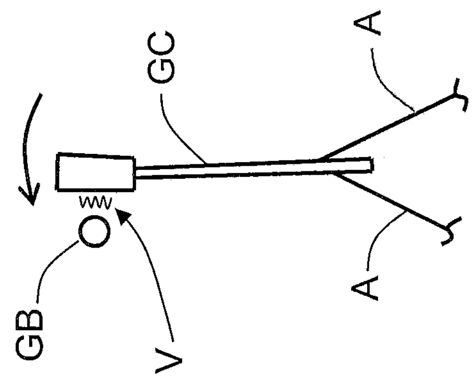


FIG. 5B

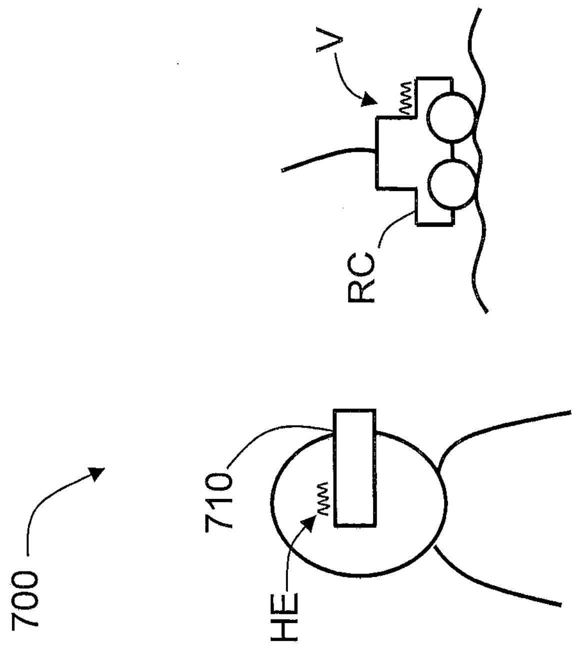


FIG. 7

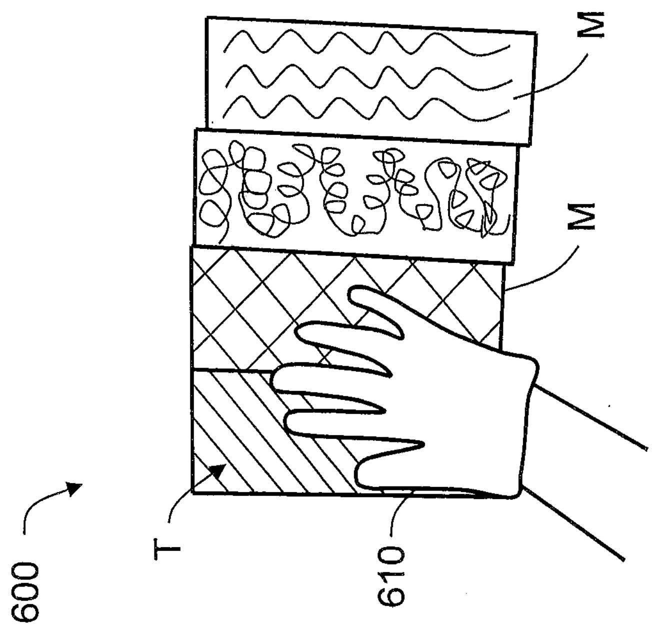


FIG. 6

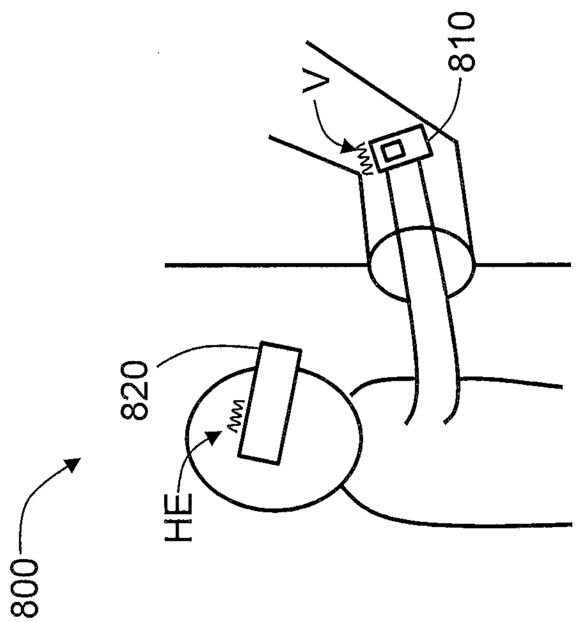


FIG. 8

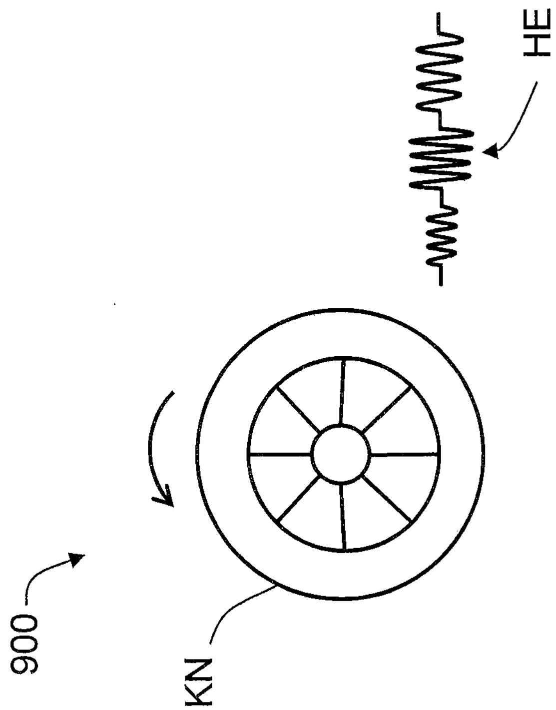


FIG. 9

SYSTEMS AND METHODS FOR RECORDING AND PLAYING BACK POINT-OF-VIEW VIDEOS WITH HAPTIC CONTENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority from U.S. Provisional Patent Application Ser. No. 61/922,648, filed Dec. 31, 2013, the entire content of which is incorporated herein by reference.

FIELD

[0002] The present invention is directed to systems and methods for recording and playing back point-of-view videos with haptic content.

BACKGROUND

[0003] Electronic devices allow users to record videos that may capture both the visual and audio aspects of an event. Electronic devices may also be programmed to provide haptic sensations while the user is watching a video played on the electronic device. The haptic sensations are typically preprogrammed so that when the video is played, the user may experience haptic effects in conjunction with the video to provide a more immersive experience for the user. Existing devices only allow the haptic effects to be determined after the video has been recorded. Currently, creating haptic effects and sensations is a labor-intensive process that is not done in real time.

[0004] A new generation of electronic devices in the form of head mounted displays, such as Google Glass, allow the wearer to record visual and audio aspects of an event from his/her point-of-view and play back so-called "point-of-view" videos. The videos may be sent to others so that the viewer may play the video back on his/her own electronic device and re-live the experience as if he/she was experiencing the event first hand.

SUMMARY

[0005] It is desirable to be able to record a point-of-view video of an event while at the same time record other real-time aspects of the event so that the real-time aspects of the event may be played back with the video as haptic sensations to provide an even more realistic and immersive experience for the viewer watching the point-of-view video and feeling haptic sensation playback.

[0006] According to an aspect of the invention, there is provided a system that includes a video recorder configured to record a point-of-view video of an event, a sensor configured to sense vibrations associated with the event, a processor configured to synchronize the recorded point-of-view video and the sensed vibrations, and a playback device that includes a display and a haptic output device. The playback device is configured to play back the synchronized point-of-view video and vibrations, and the haptic output device is configured to generate haptic effects based on the vibrations.

[0007] In an embodiment, the video recorder and the sensor are part of a first electronic device. In an embodiment, the first electronic device is a head mounted display device. In an embodiment, the processor and the playback device are also part of the head mounted display device. In an embodiment, the playback device is a second electronic device separate from and in wireless communication with the first electronic device. In an embodiment, the second electronic device is a head mounted display device.

[0008] In an embodiment, the point-of-view video comprises a training video.

[0009] According to an aspect of the invention, there is provided a method that includes recording a point-of-view video of an event with a video recorder, sensing vibrations associated with the event with a sensor while recording the point-of-view video, synchronizing the recorded point-of-view video and the sensed vibrations, and playing back the synchronized point-of-view video and vibrations with a playback device comprising a display and a haptic output device, wherein the haptic output device generates haptic effects based on the vibrations.

[0010] In an embodiment, the method further includes communicating the synchronized point-of-view video and vibrations to the playback device. In an embodiment, the communicating is completed wirelessly. In an embodiment, the communicating is at least partially completed over the Internet.

[0011] According to an aspect of the invention, there is provided a system that includes a sensor configured to sense vibrations associated with an event experienced by a user of the system, and a haptic output device configured to generate haptic effects based on the vibrations and output the haptic effects to the user as the user is experiencing the event.

[0012] According to an aspect of the invention, there is provided a method that includes sensing vibrations associated with an event with a sensor carried by a user experiencing the event, generating haptic effects based on the vibrations with a haptic output device, and outputting the haptic effects to the user as the user is experiencing the event.

[0013] These and other aspects, features, and characteristics of the present invention, as well as the methods of operation and functions of the related elements of structure and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the invention. As used in the specification and in the claims, the singular form of "a", "an", and "the" include plural referents unless the context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The components of the following Figures are illustrated to emphasize the general principles of the present disclosure and are not necessarily drawn to scale. Reference characters designating corresponding components are repeated as necessary throughout the Figures for the sake of consistency and clarity.

[0015] FIG. **1** illustrates a system in accordance with embodiments of the invention;

[0016] FIG. **2** illustrates a method in accordance with embodiments of the invention;

[0017] FIG. **3** illustrates an implementation of the system of FIG. **1** in accordance with an embodiment of the invention;

[0018] FIG. **4** illustrates an implementation of the system of FIG. **1** in accordance with an embodiment of the invention;

[0019] FIGS. **5**A and **5**B illustrate an implementation of the system of FIG. **1** in accordance with an embodiment of the invention;

[0020] FIG. **6** illustrates an implementation of the system of FIG. **1** in accordance with an embodiment of the invention;

[0021] FIG. **7** illustrates an implementation of the system of FIG. **1** in accordance with an embodiment of the invention;

[0022] FIG. **8** illustrates an implementation of the system of FIG. **1** in accordance with an embodiment of the invention; and

[0023] FIG. **9** illustrates an implementation of the system of FIG. **1** in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0024] FIG. **1** illustrates a system **100** in accordance with an embodiment of the invention. As illustrated, the system **100** includes one or more sensors **102**, which are configured to sense vibrations experienced by a user recording an event or an object that is a subject of the event, and convert the sensed vibrations into sensor data. The system **100** also includes a video recorder **104** configured to capture and record images of the event, and an audio recorder **106** configured to capture and record sound associated with the event. In an embodiment, the sensor(s) **102**, the video recorder **104**, and the audio recorder **106** may be part of the same electronic device **140**. In an embodiment, the video recorder **104** and the audio recorder **106** may be part of the same electronic device, and the sensor(s) **102** may be separate from the electronic device that includes the video recorder **104** and the audio recorder **106**. In an embodiment in which the video recorder **104** and the audio recorder **106** are part of the same electronic device, the electronic device may be a head mounted device, such as for example, Google Glass. In an embodiment, the sensor(s) **102**, the video recorder **104**, and the audio recorder **106** may be separate, stand-alone devices or part of separate, stand-alone devices.

[0025] A processor **110** is configured to process signals and data output by the sensor(s) **102**, the video recorder **104**, and the audio recorder **106**, as discussed in further detail below. The system **100** also includes an input transformer **112**, an output transformer **114**, which may be part of the processor **110**, and a decoder **116**, which may also be part of the processor **110**. Aspects of the input transformer **112**, the output transformer **114**, and the decoder **116** are discussed in further detail below.

[0026] As illustrated in FIG. **1**, the system **100** also includes a haptic output device **118** configured to output haptic effects to a user of the system, a display **120** configured to display images, such as the images captured by the video recorder **104**, and a speaker **122** configured to output sound, which may be the sound captured by the audio recorder **106**. The haptic output device **118**, the display **120**, and the speaker **122** may be part of an electronic playback device **130**, as discussed in further detail below. In an embodiment, the haptic output device **118**, the display **120**, and/or the speaker **122** may be part of a wearable device, such as a head mounted display. In an embodiment, the haptic output device **118**, the display **120**, and the speaker **122** may be separate devices that are configured to communicate with each other through a wireless connection, for example. In an embodiment, the haptic output device **118** may be part of a wearable device, the display **120** may be part of a television, and the speaker **122** may be a wireless speaker that is separate from the display **120**.

[0027] The haptic output device **118** may include an actuator, for example, an electromagnetic actuator such as an Eccentric Rotating Mass ("ERM") in which an eccentric mass is moved by a motor, a Linear Resonant Actuator ("LRA") in which a mass attached to a spring is driven back and forth, or a "smart material" such as piezoelectric, electro-active polymers or shape memory alloys, a macro-composite fiber actuator, an electro-static actuator, an electro-tactile actuator, and/or another type of actuator that provides physical feedback such as a haptic (e.g., vibrotactile) feedback. The haptic output device **118** may include non-mechanical or non-vibratory devices such as those that use electrostatic friction (ESF), ultrasonic friction (USF), or those that induce acoustic radiation pressure with an ultrasonic haptic transducer, or those that use a haptic substrate and a flexible or deformable surface, or those that provide projected haptic output such as a puff of air using an air jet, and so on.

[0028] Electronic memory **124** may be used to store data sensed by the sensor(s) **102**, electronic memory **126** may be used to store data that is recorded by the video recorder **104**, and electronic memory **128** may be used to store data that is recorded by the audio recorder **106**. The memory **124**, **126**, **128** may include one or more internally fixed storage units, removable storage units, and/or remotely accessible storage units. The various storage units may include any combination of volatile memory and non-volatile memory. The storage units may be configured to store any combination of information, data, instructions, software code, etc. In embodiments in which the sensor(s) **102**, the video recorder **104**, and the audio recorder **106** are part of the same electronic device **140**, the memory **124**, **126**, **128** may be co-located. In embodiments in which the video recorder **104** and the audio recorder **106** are part of the same electronic device, the memory **126**, **128** may be co-located.

[0029] In an embodiment, a user may record video and/or audio of a scene or event using the video recorder **104** and/or the audio recorder **106**. In an embodiment, the video recorder **104** and the audio recorder **106** may be part of the same recording device, such as a video camcorder, a smartphone, a head mounted recording device, etc. The video and audio that is recorded may be stored in the electronic memory **126**, **128**, as discussed above. In an embodiment, the sensor(s) **102** may be placed on an object of interest, such as on the user recording the event or on an article the user is in contact with as the user is recording the event. In an embodiment, the sensor(s) **102** may be placed on an object of interest in the event that is remote from the user recording the event.

[0030] As discussed above, the data generated by the sensor(s) **102** may be stored in the electronic memory **124**. In addition, the data generated by the sensor(s) **102** may be transformed by the input transformer **112** prior to being stored in the electronic memory **124**, as illustrated in FIG. **1**. The transformation of the sensor data is considered to be an optional step and whether the transformation is needed may depend on the nature of the sensors being used. Details of embodiments of the sensor **102** are discussed in further detail below.

[0031] The decoder **116**, which may be part of a media player configured to playback the video, i.e. media file, is configured to read the data generated by the sensor(s) **102** from the electronic memory **124**, and associate the data temporally with the audio data and video data that were recorded and stored in the electronic memory **126**, **128**. During media playback, the decoder **116** may pass the sensor data through an output transformer **114** configured to transform the sensor data into a haptic output signal to generate one or more haptic effects or haptic sensory commands, which include but are not limited to, vibration, surface friction modulation, skin pinch, skin squeeze, etc. The decoder **116** may be configured to synchronize the haptic output signal that was transformed from the sensor data with the video data and the audio data so that the haptic effect is synchronized with the video and audio during playback. In an embodiment, the synchronization may be completed by ensuring that time is the same in the video data, the audio data, and the haptic effect during playback.

[0032] The processor **110** may be a general-purpose or specific-purpose processor or microcontroller for managing or controlling the operations and functions of the system **100**. For example, the processor **110** may be specifically designed as an application-specific integrated circuit ("ASIC") to control output signals to the haptic output device **118** to provide haptic effects. The processor **110** may be configured to decide, based on predefined factors, what haptic effects are to be generated, the order in which the haptic effects are generated, and the magnitude, frequency, duration, and/or other parameters of the haptic effects. The processor **110** may also be configured to provide streaming commands that may be used to drive the haptic output device **118** for providing a particular haptic effect. In some embodiments, the processor **110** may actually be a plurality of processors, each configured to perform certain functions within the system **100**. The processor **110** may also include memory that includes one or more storage devices that may include haptic effect profiles, instructions for how the haptic output device **118** is to be driven, and/or other information for generating haptic effects. In an embodiment in which the entire system **100** illustrated in FIG. **1** is part of a single electronic device, the memory **124**, **126**, **128** may be part of the processor **110**.

[0033] The haptic output signal may then be transmitted from the processor **110**, e.g., from the decoder **116** of the processor **110**, to the haptic output device **118** so that the person(s) experiencing the media through the electronic playback device **130** that includes the haptic output device **118** may more fully experience the event being played back. The electronic playback device **130** may be any device, such as an electronic handheld device, such as a mobile phone (i.e. smartphone), gaming device, personal digital assistant ("PDA"), portable e-mail device, portable Internet access device, tablet, etc. The electronic playback device **130** may include, but is not limited to, a handheld device or wearable device with the display **120**, which may be a high definition display, that displays the media, and a handheld object that is capable of producing haptic sensations or effects, or an object attached to the user's body, leaning up to the user's body, or otherwise able to transmit tactile sensations and haptic effects to the user.

[0034] In an embodiment, the processor **110** and the haptic output device **118** may be part of an electronic handheld device, which may be a phone or a tablet, or a wearable device, such as a smartwatch, bracelet, necklace, headband, glasses, head mounted display, etc., and the electronic handheld device may be configured to output the video data to a separate display **120**, which may be a television. In this embodiment, the user playing back the event may watch the event on a television and feel the vibrations associated with the event on the electronic handheld device.

[0035] In an embodiment, the sensor **102**, the video recorder **104**, the audio recorder **106**, the input transformer **112**, and associated memory devices **124**, **126**, **128** may be part of the same electronic device **140**. In an embodiment, the electronic device **140** may be a head mounted display device. In an embodiment, the electronic playback device **130** may be the same device as the electronic device **140** that includes the sensor **102**, the video recorder **104**, and the audio recorder **106**. In an embodiment, the electronic playback device **130** and the electronic device **140** may be configured to communicate with each other through a wireless connection, for example. In an embodiment, the entire system **100** illustrated in FIG. **1** may be part of the same electronic device, which may be a head mounted display device.

[0036] In an embodiment, the system **100** may include a mobile phone or a wearable compact electronic device having a gyroscope, a compass, and three-axis accelerometer sensors for the sensors **102**, as well as a built-in camera for the video recorder **104**. In this instance, all of the components illustrated in FIG. **1**, including the data recording sensors **102**, video recorder **104**, audio recorder **106**, processor **110** including the decoder **116** and output transformer **114**, haptic output device **118**, display **120**, speaker **122**, input transformer **112**, and electronic memory **124**, **126**, may be self-contained, and the entire system **100** may be affixed to the person or a piece of equipment performing an activity of interest.

[0037] In an embodiment, a first-person perspective video camera may be mounted to a helmet or piece of equipment performing the activity of interest, and the video camera may incorporate a number of data sensors **102**, such as accelerometers, a global positioning system ("GPS"), and gyroscopes, the input transformer **112**, if needed, the electronic memory **124**, the video recorder **104**, the audio recorder **106**, and the electronic memory **126**. The remaining parts of the system **100**, such as the processor **110** including the decoder **116** and output transformer **114**, the haptic output device **118**, the display **120**, and the speaker **122**, may be located in a separate playback device, such as the electronic playback device **130** discussed above.

[0038] In an embodiment, the sensor(s) **102**, which may include one or more data sensors, such as accelerometers, laser vibrometers, GPS, etc., may be affixed either to the person or to equipment performing the activity of interest. The sensor(s) **102** may be contained in a sensor box, or some other container that is configured to protect the sensor(s) **102**. The sensor box may have data recording means, such as the input transformer **112** and the electronic memory **124**, built-in, or may rely on a data connection to secondary device (such as a mobile device) to record the data during the activity.

[0039] In an embodiment, the vibrations experienced by the person operating the video recorder **104** may be recorded using a sensor **102** in the form of an accelerometer that is directly or indirectly connected to the video recorder **104**. The accelerometer may, for example, be integrated in the video recorder **104** or be mounted on the user's equipment, such as for example a bicycle, or on a wearable article, such as for example a bracelet. In an embodiment, the sensor **102** may be in the form of a laser vibrometer that is provided on the person experiencing the vibrations or elsewhere. In an embodiment, vibrations may also be inferred from the motion of the video image, or from the sound recorded by the audio recorder **106** along with the video. The intensity of the vibrations may, for example, be inferred from the shakiness of the recorded video. The sound may similarly be analyzed to detect noise related to vibrations, or discrete events such as impacts. In an embodiment, vibrations may be recorded through bone-conduction transducers that are sometimes used for audio output.

[0040] In an embodiment, smart filtering or transforming may be used by the processor **110** to remove noise from the vibration recording. The vibrations caused by touch input on a head mounted recording device, for example, may need to be modeled and removed from the recording if measurements are taken on the frame of the head mounted recording device. The video may be taken from different points of view, including a view from the front, back or side of the head mounted recording device, a view from a handheld camera, such as that of a smartphone, a view from a robot, such as a telepresence robot and/or a view from a remote controlled vehicle, for example.

[0041] In an embodiment, a recording session may be initiated in which the stream of sensor data is recorded alongside the video and audio data. The video recorder **104** and/or audio recorder **106** may be worn or otherwise carried by the person recording the event. The synchronization of all of the data streams containing vibration, video, and audio data may be managed by recording software, which may reside in the processor **110** of the system **100** illustrated in FIG. **1**.

[0042] In an embodiment, flexible container formats, such as MPEG-4, that allow for the storage of data other than video and audio in a single file container, may be used. In such an embodiment, a particular set of encoders may be used to place the sensor data into the MPEG-4 file during recording. In an embodiment, special software may be written to store the non-audio and video (A/V) sensor data in a separate file, but with special markers in the sensor data to allow for proper synchronization at playback time. In this embodiment, very little input transformation may need to be applied, beyond shaping the sensor data to conform to the limitations of the designed recording format. The exact format may be determined by the implementer. Once the person recording the event has completed his or her activity, the recording may be stopped. The MPEG-4 file may be closed, and all of the sensor data may reside in the MPEG-4 file.

[0043] In an embodiment, the playback device may be the electronic playback device **130** of FIG. **1**, and may be in the form of a mobile phone or tablet having the display **120**, the speaker **122**, and a vibration device as the haptic output device **118** to provide the haptic effect. In an embodiment, the playback device may be a gaming console connected to a television having the display **120** and the speaker **122**, and also connected to a gaming peripheral, such as a gamepad, that includes the haptic output device **118** to provide the haptic effect.

[0044] Either at a later time, or concurrently with the activity being performed, one or more viewers may be interested in experiencing the activity. To play back the activity, the viewer may launch the appropriate playback software on their playback device with the objective of experiencing the performer's activity from the performer's point-of-view. In an embodiment, the playback software may include a player software application that incorporates the sensor decoding scheme performed by the decoder **116**, as well as output transform software that may be run by the output transformer **114**, in order to transform the sensor data into a haptic output signal suitable for the haptic output device **118** in the playback device **130**. In an embodiment, a player software application may incorporate the sensor decoding scheme. The player software may rely on the output transform software being resident or otherwise pre-installed on the playback device, and such output transform software may transform the sensor data into the haptic output signal suitable for the haptic output device **118** in the playback device. In other words, the output transformer **114** and/or decoder **116** may be located on the playback device **130**.

[0045] In an embodiment, a player software application may rely on the playback device's operating system software to perform the media playback, which incorporates the sensor decoding scheme. The operating system software may rely on the output transform software being resident or otherwise pre-installed on the playback device, and such output transform software may transform the sensor data into a haptic output signal suitable for the haptic output device **118** in the playback device. The viewer may then experience haptic sensations associated with the viewing of the performance, such haptic sensations being produced by the output transform software.

[0046] The video and sensor data streams may then be synchronized, merged, and transmitted to the playback device **130**. The synchronization may, for example, be done by including a timestamp on every video frame and sensor measurement, keeping in mind that the capture may take place on independent devices that communicate through a wired or wireless network. The recording device may therefore need to obtain a shared time reference, for example from a GPS system. Alternatively, synchronization may be performed by performing a specific action that is detectable in both the video and the sensor data streams, such as jumping up and down three times.

[0047] The resulting data may be transmitted as a single data stream combining both vibrations and video, or as two data streams with synchronization information. The data stream may be transmitted gradually to the playback device, or stored in a file for later playback. In an embodiment, the haptic feedback may be produced offline using editing tools and added to the point-of-view video in post-production.

[0048] The point-of-view video may be played back at a later time or streamed in real time, in both cases either by one or more recipients. The video may be played back on several devices, including but not limited to: smart glasses (e.g., Google Glass), smartphones or tablets, computers, home theater systems, etc.

[0049] In an embodiment, the haptic feedback may be immediately played back to the person making the recording either to monitor the quality of the feedback or to amplify the haptic experience. The haptic feedback may similarly be produced using different haptic output devices located on a smartphone or a tablet, a wearable device, such as a head mounted display device, a smartwatch, a wristband, a ring or a glove, or a piece of furniture, such as a chair or a table.

[0050] The playback device should be capable of decoding the stream of video and vibrations, and maintaining the synchronization between the video and vibrations. A single microcontroller in the playback device **130** may, for example, control both the video display **120** and the haptic output device **118** based on the video and vibration streams.

[0051] FIG. **2** illustrates a method **200** in accordance with an embodiment of the invention. At **210**, a video is recorded by a recording device, such as the video recorder **104** described above. At **220**, vibrations are sensed by a sensor, such as the sensor **102** described above. At **230**, the video and the vibrations are synchronized using a processor, such as the processor **110** described above. At **240**, the synchronized video and vibrations are played back using an electronic playback device, such as the electronic playback device **130** described above that includes the display **120** and the haptic output device **118**.

[0052] FIGS. **3-9** illustrate various exemplary implementations of embodiments of the system **100** described above. These implementations and embodiments are not intended to be limiting in any way.

[0053] FIG. **3** illustrates an embodiment **300** of the system **100** described above in which a user is recording a point-of-view video of a stunt while snowboarding with a head mounted display device **310** that includes a video recorder and at least one vibration sensor. The user may later post the video with the embedded haptic track on the Internet so that his/her friends may watch the video on their electronic playback devices **320**, such as tablets, each equipped with a display **322** and at least one haptic output device **324** so that haptic effects HE generated by the haptic output device **324** and representative of the vibrations V recorded by the user may be felt by the user's friends as if they were there with the user. The vibration sensor worn by the user allows the user's friends to feel all of the vibrations felt by the user during the stunt, especially the impact as he/she lands hard after a jump.

[0054] FIG. **4** illustrates an embodiment **400** of the system **100** described above in which a user is recording a point-of-view video of a particularly rough ride as he/she is mountain biking with a head mounted display device **410**. The user is also recording the vibrations V of the bike and feeling the vibrations amplified on his/her back through haptic effects HE generated by a haptic output device **420** mounted on the user's back or head mounted display device **410**. The amplified vibrations created as the haptic effects HE may make the ride even more thrilling for the user.

[0055] FIGS. **5**A and **5**B illustrate an embodiment **500** of the system **100** described above that is used by a user to record a point-of-view training video for golf with a head mounted display **510**, from the user's perspective, so that the user may share the video with his/her students. FIG. **5**A is a schematic perspective view of the user wearing a head mounted display **510** and holding a gold club GC with his/her arms A extended. The vibrations V associated with striking a golf ball GB with the golf club GC are also recorded. Upon playback, the students may see the user's tips from his/her perspective, as illustrated in FIG. **5**B and "feel" the impact of the golf club GC with the golf ball GB. When playing back the video on their own head mounted display devices, the students may watch the video as they practice their own swings.

[0056] FIG. **6** illustrates an embodiment **600** of the system **100** described above in which the user has a blog about industrial design in which he/she often talks about new materials M that he/she has found. The user may use a head mounted display and a special glove **610** with sensors that allow the user to record textures T and share his/her experience as he/she feels the new materials M. This allows members of the audience of the blog to feel the textures T of the new materials M on their smartphones or, in some cases, with their own gloves, provided the smartphones or gloves include haptic output devices that can play back the recorded textures T, such as through the generation of electrostatic friction or ultrasonic surface friction haptic effects.

[0057] FIG. **7** illustrates an embodiment **700** of the system **100** described above in which the user interacts with a remote controlled car RC through a head mounted display device **710**, which includes a video display and a haptic output device, such as the video display **120** and the haptic output device **118** described above. A point-of-view video recorder and vibration sensor may be mounted in the car RC and signals may be transmitted from the video recorder and the vibration sensor to the head mounted display device **710**. This may allow the user to see from the perspective of the car RC and feel the vibrations V of the car RC as haptic effects HE generated by the haptic output device, as if he/she was inside the car RC.

[0058] FIG. **8** illustrates an embodiment **800** of the system **100** described above in which the user uses his/her smartphone **810** equipped with a camera and vibration sensor to see inside an industrial machine that he/she is repairing. The embodiment **800** depicted in FIG. **8** includes a head mounted display device **820** that that may be worn by the user and configured to display the images being taken by the camera of the smartphone **810**. The head mounted display device **820** also includes a haptic output device, such as the haptic output device **118** described above. This allows the user to see from the point-of-view of the camera of the smartphone **810** and feel the vibrations V generated in the machine as the smartphone **810** bangs or brushes against the machine via haptic effects HE provided by the haptic output device.

[0059] FIG. **9** illustrates an embodiment **900** of the system **100** described above that allows the user to watch an instructional video on a head mounted display device to learn how to fix a machine. As the instructor shows in the point-of-view video how to turn a knob KN until it is tight, the user can feel the sensations that he/she should try to reproduce via a haptic effect HE that is generated by a haptic output device located in the head mounted display device.

[0060] The above-described implementations of embodiments of the invention are not intended to be limiting in any way. For example, although the implementations described above may involve the sensing of vibrations, other signals that may be used as a basis of or a contributing factor to a haptic effect to be generated may be used. For example, signals based on movements of the user or an object of interest (e.g. the chest of a person expanding and contracting while breathing), vertical motion and altitude of a user or an object of interest, orientation of a user or object of interest (e.g. tilt of a skier leaning left or right in a curve), contact with or distance from the ground (e.g., jumping while skiing or biking), pressure applied by a user against an object of interest (e.g. pressure against a seat or handles of a bicycle), displacement of a component of an object of interest (e.g., chucks of a mountain bike), environmental conditions, such as temperature, wind speed, etc. The haptic effects that are generated may be based on such other signals, and any type of haptic feedback may be used to represent such signals, including but not limited to motion, force, deformation, squeezing, temperature changes, etc.

[0061] In some implementations of embodiments of the invention, the sensing may be directly mapped to an output. For example, the sensed tilt of a skier may be replicated with a motion platform. In some implementations of embodiments of the invention, the system may transform the input to in order to be output by the haptic output device. For example, pressure against a handle of a bicycle may be mapped to vibrations.

[0062] In some implementations of embodiments of the invention, the video may be recorded with a video recorder being held by a user of the system, but instead of recording an event from the user's point-of view, the video recorder may be pointed in a different direction. For example, a camera on a head mounted display may point to a different direction other than where the user is looking. A diver, for example, may have a camera pointed straight up from his/her head so that the camera points towards the water when diving. In other words, the point-of-view is not necessarily coincident with the user's eyes, but may instead be coincident with a leading part of the user's body, etc.

[0063] The embodiments described herein represent a number of possible implementations and examples and are not intended to necessarily limit the present disclosure to any specific embodiments. Instead, various modifications can be made to these embodiments as would be understood by one of ordinary skill in the art. Any such modifications are intended to be included within the spirit and scope of the present disclosure and protected by the following claims.

What is claimed is:

1. A system comprising:
a video recorder configured to record a point-of-view video of an event;
a sensor configured to sense vibrations associated with the event;
a processor configured to synchronize the recorded point-of-view video and the sensed vibrations; and
a playback device comprising a display and a haptic output device, the playback device being configured to play back the synchronized point-of-view video and vibrations, and the haptic output device being configured to generate haptic effects based on the vibrations.

2. The system according to claim **1**, wherein the video recorder and the sensor are part of a first electronic device.

3. The system according to claim **2**, wherein the first electronic device is a head mounted display device.

4. The system according to claim **3**, wherein the processor and the playback device are also part of the head mounted display device.

5. The system according to claim **2**, wherein the playback device is a second electronic device separate from and in wireless communication with the first electronic device.

6. The system according to claim **5**, wherein the second electronic device is a head mounted display device.

7. The system according to claim **1**, wherein the point-of-view video comprises a training video.

8. A method comprising:
recording a point-of-view video of an event with a video recorder;
sensing vibrations associated with the event with a sensor while recording the point-of-view video;
synchronizing the recorded point-of-view video and the sensed vibrations; and
playing back the synchronized point-of-view video and vibrations with a playback device comprising a display and a haptic output device, wherein the haptic output device generates haptic effects based on the vibrations.

9. The method according to claim **8**, wherein the point-of-view video comprises a training video.

10. The method according to claim **8**, further comprising communicating the synchronized point-of-view video and vibrations to the playback device.

11. The method according to claim **10**, wherein the communicating is completed wirelessly.

12. The method according to claim **10**, wherein the communicating is at least partially completed over the Internet.

13. A system comprising:
a sensor configured to sense vibrations associated with an event experienced by a user of the system; and
a haptic output device configured to generate haptic effects based on the vibrations and output the haptic effects to the user as the user is experiencing the event.

14. A method comprising:
sensing vibrations associated with an event with a sensor carried by a user experiencing the event;
generating haptic effects based on the vibrations with a haptic output device; and
outputting the haptic effects to the user as the user is experiencing the event.

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