(12) **EUROPEAN PATENT APPLICATION**

(54) **Motion tracking apparatus**

(57)   The present invention proposes an apparatus for sensing a position p[k] of a monitor object (100) located relative to a reference object (200). The position p[k] is provided in form of measurement data $m_1[k]$, $m_2[k]$. Therein, the apparatus (120a, 120b) includes measurement means for measuring at least a first characteristic of a first transmission path (s_1) and a second characteristic of a second transmission path (s_2) based on at least one signal a(t), wherein the first and second transmission path connecting the monitor object (100) and the reference object (200) for signal transmission are at least partly spaced to each other, and for generating the measurement data $m_1[k]$, $m_2[k]$ based on at least the first and second characteristics. The first and second characteristics are preferably a signal damping or a signal delay. The present invention further proposes a multimedia system utilizing the motion tracking apparatus (120a, 120b) according to the invention and a method to determine the position p[k] of an object (100). The motion tracking apparatus according to the invention is technically simple, light weighting and cost effective.
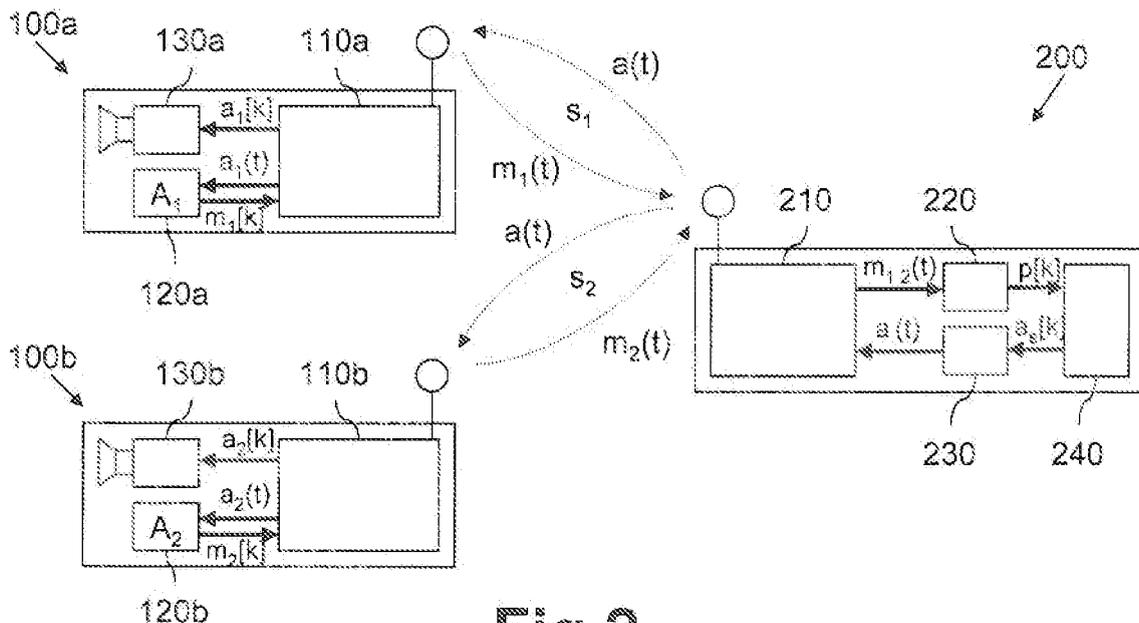
Fig.2

EP 2 136 577 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to an Apparatus for motion tracking and to a method for determining the position or orientation of a monitor object in relation to a reference object. Further, it relates to a multimedia system applying the motion tracking apparatus.

BACKGROUND OF THE INVENTION

[0002] Electronic output apparatuses enable a user to receive multimedia data from a signal processing unit. As for example, an electronic output apparatus may be a speaker or a monitor. The signal processing unit may be a video, HIFI or game console. In this technical field, there is a high economical demand on the relevant market (game industry, medical audiovisual aids, ...) and a high variety of technical development potentialities.

[0003] Exemplary, the hardware for playing a video game could be roughly divided into a game console as signal processing unit and an input/output unit including the electronic output apparatus. Therein, the input/output unit may be a vibrating joystick sensing input data from the user to control a game and outputting vibration signals dependent on the state of the game. Game console and input/output unit communicate with each other during their operation. Since this communication can include a large amount of data to be exchanged, both units require a powerful internal operation and an effective communication port.

[0004] In the video game, the input/output unit must be able to simulate the reality as close as possible. Therefore, motion tracking apparatuses have been proposed to track the movement of a user and to make the game play dependent on his movement.

[0005] The very first motion tracking apparatuses were realized as head set including a head tracker, which senses the movement of the player's head based on transducers like accelerometers, gyroscopes, magnetometers, etc and provides it as input data to the console. On the other side, the console calculates multimedia data based on input data and provides it as output data to speakers included in the headset.

[0006] However, existing headsets for motion tracking are expensive, bulky and require a high input power. This is an important reason why motion trackers are still not used in e.g. portable game consoles. The main reason for the foregoing disadvantages are conventional transducers included in conventional motion tracking apparatuses. Further, even with a combination of conventional transducers and complex mathematics, it is still not possible to provide the most significant information completely (i.e. head rotation and distance relative to the console).

[0007] US 6,532,291 describes a headset including a rotational acceleration sensor as head tracker. The data measured by the head tracker are wirelessly transmitted from the headset to a console. On the other hand, the multimedia data to be presented by speakers are transmitted cable bounded from the console to the headset. Thus, head tracking and multimedia communication are two different electronic systems. Due to a high power consumption, a cable connection between the headset and the console is essential to provide a sufficient long operation time of the headset. The headset provides the head rotation angle respectively only to the z-axis. However, effective motion tracking requires the rotation angle and the displacement respectively to all coordinate axes. In the prior art, this could be achieved only by including further transducers increasing the complexity of the system and therewith the power consumption and the production costs.

OBJECT AND SUMMARY OF THE INVENTION

[0008] Therefore, it is an object of the present invention to reduce the technical complexity of a motion tracking apparatus.

[0009] The inventor recognized, that signals will be modified differently if they pass different transmission paths. A transmission path is characterized by a transmitter for sending a signal as a start point and a receiver for picking up the signal. Since the signals are modified based on the transmission path, the characteristics of the transmission path can be used to determine the distance between a transmitter and a receiver. This distance can be used to determine the position in space of a monitor object. Such a monitor object may be a headset of a user to determine to position of its head. Based on the amount of dimensions for the position in space to be determined, two or three different distances between a reference object and this monitor object are necessary. Thus, the characteristics of two or three different transmission channels must be determined at first. Once, these characteristics are known, the position in space may be directly derived or derived via the distances as mentioned above. Thus, the invention is based on the thought to determine the characteristics of at least two different transmission paths between a reference object located relatively to a monitor object. Once these characteristics are known, all necessary information to calculate the position in space of the monitor object is available.

[0010] Therefore, the invention proposes an apparatus to provide measurement data for determining the position in space of a monitor object located relatively to a reference object. According to the invention, the motion tracking apparatus determines a signal distortion or channel characteristic of at least a first and a second transmission path based on a predetermined signal characteristic of at least one signal as the measurement data. The first and second transmission paths are located between the monitor object and the reference object and are at least partly spaced to each other.

[0011] Since the signal distortion is a direct indicator for the characteristics of the first and second transmission path, the motion tracking apparatus according to the present invention is able to determine distances of the first and second transmission paths between the monitor object and the reference object and therewith the position in space of the monitor object. Thus, the motion tracking apparatus not requires any further bulky sensors for determining an acceleration or the like for determining the position in space of the monitor object. Therefore, the motion tracking apparatus can be realized by a light-weighting signal processing unit without further heavy sensors requiring a high operational power. Thus, the motion tracking apparatus can be embodied cost effective, handy and with low power consumption. Therefore, the present invention provides a low complex motion tracking apparatus.

[0012] Multimedia applications like video games and HiFi-applications require light weight motion tracking apparatuses to increase the users experience in enjoying the multimedia application. Thus, the monitor object may preferably be a headset and the reference object may preferably be a multimedia device providing video and/or sound depending on the position of the monitor object. Since the motion tracking apparatus according to the present invention does not require any heavy transducer as sensor for capturing the motion of the monitor object, the weight is drastically reduced and therefore very suitable to be applied in multimedia applications, even if the multimedia application is portable.

[0013] The signal distortions may be determined based on the damping and/or the signal delay on the transmission paths. These are technically the most simple measures for determining a signal distortion.

[0014] The signal distortions may be determined based on one signal, which is transmitted via the first and via the second transmission path. This would save signal bandwidth.

[0015] In a preferred embodiment, the monitor object may be a headset including a left and a right ear bud. Each ear bud may include an autonomous wireless device placed in or over an ear of a user or listener. Unlike to conventional headsets including ear buds that are physically wired together, the present embodiment includes ear buds that receive signals independently to each other. As already explained, conventional headsets for motion tracking include bulky and cost intensive sensors for motion tracking mounted additionally on the headset. In contrary thereto, a headset including the motion tracking apparatus according to the present invention uses merely basic electronic elements but no additional sensors for determining a position of the headset. This reduces the weight of the overall headset. Such a light weight headset is important for a player, since it enables a user to feel the movement of its head very realistic without feeling the weight of the sensor included in the headset. A further advantage is that the costs are minimal in respect to motion tracking apparatuses including conventional position sensors.

[0016] The motion tracking apparatus can be further improved, if the signal required to determine the position of the monitor object is used to transmit the usual data traffic within the electronic system applying the motion tracking apparatus, e.g. audio or video data. The signal may be a media stream, in particular a modulated multimedia stream. Since the signal for determining the position based on the channel characteristic is derived from the normal data traffic of the electronic system using the motion tracking apparatus, the transmission of an extra signal for determining the position can be omitted saving frequency bandwidth on the one hand and hardware to transmit the signal on the other hand. Therefore, the complexity of the motion tracking apparatus is drastically reduced.

[0017] In a preferred embodiment the motion tracking apparatus is integrated it into existing systems without any further amendments on the existing system operating wirelessly. Such systems include at least a first receiver and a second receiver locally displaced to each other. These receivers are used in the motion tracking apparatus, wherein each receiver receives the signal independently to each other. Since the first and second receivers are locally displaced to each other, a signal transmitted from a signal source is received in the first and second receiver over the two different transmission paths. Thus, a first and second transmission path is realized without the need to amend the system into which the motion tracking apparatus should be integrated. The only requirement is to send the measurement data back to the transmitting source. Therein, the position of the monitor object could be calculated based on the measurement data.

[0018] The signals or measurement data, which needs to be evaluated to determine the position of the monitor object include a lot of suitable indicators, like power strength and signal delay. However, as known to a skilled person, the signal strength in the near field of the signal reference object will be weakened with the power of six in respect to the length of the transmission path. Thus, the motion tracking apparatus preferably determines and measures at least one signal strength indicator indicating a signal amplitude of the received signal as the measurement data. By that means, the length or distance of each transmission path between the monitor object and the reference object could be determined up to some centimeters without high measurement errors. The further determination of the position of the monitor object can then be performed based on elementary mathematics. Thus, by measuring the signal amplitude, the motion tracking apparatus can be further simplified.

[0019] Some amplitude measurement procedures to determine the amplitude of a signal, are very prone to interfer-

ences, e.g. peak-peak amplitude determination. Therefore, the motion tracking apparatus may determine the root-mean-square amplitude of the signal. The measurement of the root-mean-square amplitude is very immune to interferences such that the present embodiment provides an optimal performance of the motion tracking apparatus.

[0020] Due to the non-linear dependency of the amplitude in respect to the length of the transmission path, the amplitude would fluctuate strongly in case of long transmission paths. In case of short transmission paths, the amplitude would keep nearly constant. This would lead to a limited measurement range for the signal amplitude. Therefore, the signal amplitude may be measured logarithmically. Since, the signal strength in the near field of the signal reference object will be weakened with the power of six in respect to the length of the transmission path, the logarithmical measurement would provide a more constant measurement accuracy in a wide measurement range as the signal amplitude is increased.

[0021] The light weight of many electronic applications applying the motion tracking apparatus requires that the electronic component into which the motion tracking apparatus is implemented would comprise as less additional components as necessary. Thus, the motion tracking apparatus may transmit the measurement data back to the source of the signal for further data processing. Since the motion tracking apparatus is usually implemented into an input/output unit of a multimedia application being the monitor object, the real data processing for determining the position can be performed only by a console being the reference object. By postponing the measurement data back to the console as early as possible, the technical complexity of the motion tracking apparatus is kept minimal, which further reduces the overall weight.

[0022] By re-transmitting the measurement data back to the signal source, the present invention requires a bidirectional communication. This could be achieved in its simplest form via two forward paths and to backward paths. However, it is also possible to reduce the number of required paths to two and to use a path in a multiplexing way, e.g. in time division multiplexing way. This requires at least three independent logical transmission channels, two for providing the signal to the motion tracking apparatus and for measuring the measurement data for determining the position of the monitor object and one logical channel for returning the measurement data back to the signal source. Two of the channels, namely to receive the signal and to transmit the measurement data, may be realized by time division multiplexing. This would reduce the occupied signal bandwidth and the physical interferences between the signals.

[0023] To keep the communication traffic between the monitor object and the reference object as low as possible, the motion tracking apparatus may sub-sample, filter and/or compress the measurement data after deriving the measurement data. By doing this, the amount of measurement data to be transmitted back can be adapted to the requirements of the overall system. Criteria for the sub-sampling factors can be the channel quality, the required measurement data to unambiguously determine the position of the monitor object and/or the actual state of the monitor object (e.g. in case the monitor object is moving, provide a lower sub-sampling rate that in case the monitor object is stopping).

[0024] The motion tracking apparatus can be implemented in a plurality of electronic components, e.g. the monitor object, the reference object or an independent third object. However, the invention works best, if the motion tracking apparatus is included in the monitor object, since the requirements for signal transmission and the number of paths in this embodiment are minimal.

[0025] The present invention further proposes a multimedia system for providing multimedia data on a multimedia output device depending on a motion of the multimedia output device. This multimedia system includes a multimedia transmitter, e.g. a console and a multimedia receiver, e.g. a headset. The multimedia transmitter wirelessly transmits the multimedia data to the multimedia receiver. The multimedia receiver includes a motion tracking apparatus as described above and wirelessly transmits measurement data back to the multimedia transmitter based on the multimedia data.

[0026] In a preferred embodiment, the multimedia transmitter may be a game console, since the present invention is very suitable for video game systems, wherein the motion tracking apparatus is used as input unit for receiving input data from a player for the game play.

[0027] The multimedia receiver may determine a relative rotation angle β of the multimedia receiver based on the measurement data and the spatial distance d_{ab} between the first and second transmission path, since this determination can be performed based on elementary mathematics.

[0028] One possibility may be to determine the length d_a of the first transmission path and the length d_b of the second transmission path, such that the relative rotation angle β would result into the equation $\beta \cong \dfrac{d_a - d_b}{d_{ab}}$.

[0029] The object is further solved by a method for sensing a position of a monitor object based on measurement data including information about the position of the monitor object located relative to a reference object, the method comprises the steps of: determining a characteristic of at least a first transmission path and a second transmission path arranged between the monitor object and the reference object, wherein the first and second transmission path are located between the monitor object and the reference object and at least partly spaced to each other; and calculating measurement data at least based on the determined characteristics and calculating the position of the monitor object based on the meas-

urement data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]   The invention will be described in greater detail hereinafter, by way of nonlimiting examples, with reference to the embodiments shown in the drawings.

Fig. 1 is a video gaming system including a motion tracking apparatus according to the present invention;
Fig. 2 is a detailed diagram of the video system shown in Fig.1 and including a motion tracking apparatus according to a first embodiment of the present invention;
Fig. 3 is an embodiment for a near-field magnetic induction transceiver implemented in the video gaming system according to Fig.2;
Fig. 4 is an embodiment for a received signal strength indicator filter implemented in the video gaming system according to Fig.2;
Fig. 5 is a diagram for explaining an exemplary calculation scheme for calculating the position of the headset shown in Fig.1;
Fig. 6 is a detailed diagram of the video system shown in Fig.1 and including a motion tracking apparatus according to a second embodiment of the present invention; and
Fig. 7 is a detailed diagram of the video system shown in Fig.1 and including a motion tracking apparatus according to a third embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0031]   The motion tracking apparatus according to the present invention could be implemented into a plurality of different systems. Examples are medical applications like hearing aids, HiFi-applications like amplifiers for providing music depending on the listener's position or input/output units for video games. In the following detailed description, the principle of the motion tracking apparatus according to the present invention should be explained based on a video gaming system.

[0032]   Fig. 1 is a video gaming system including a motion tracking apparatus according to the present invention. The video system includes a headset 100 and a game console 200 wirelessly connected to each other. The headset 100 receives an audio signal a(t) from the console 200 including audio data to be presented to a user. On the other hand, the console 200 receives a measurement or motion signal m(t) from the headset 100 including information about the position of the headset 100.

[0033]   The headset 100 representing the monitor object receives the audio signal a(t) and derives based thereon information about its own position. These information are then included into the measurement signal m(t) and transmitted back to the console 200 or any other processing means able to calculate a position of the headset 100 based on the measurement data. The derived information can be each suitable information, which allows the console 200 to unambiguously determine the position in an arbitrary coordinate system. Examples for the derived information may be Cartesian, cylindrical or sphere coordinates or relative information about a position change of the headset 100. Further examples are signal characteristics of the audio signal a(t) depending on the position of the headset 100. As described later, in the preferred embodiment the measurement signal m(t) includes amplitude values of the audio signal a(t) received at different receivers having different positions at the headset 100.

[0034]   The headset 100 is not limited to mere headphones. It can be enhanced by glasses including a monitor to provide pictures to the user depending on the position of its head. In this case, the signal a(t) would include audio and video data to be presented to the user.

[0035]   The console 200 may be a personal computer, which provides the audio data via the audio signal a(t) to the headset 100. The video data are presented on an extern monitor indicated in Fig.1. It should be outlined, that even if the present embodiment shows a personal computer as console 200, the motion tracking apparatus according to the present invention especially allows to realize miniaturized video gaming systems. Thus, the present invention is especially suitable for consoles 200 being portable electronic devices.

[0036]   Fig. 2 represents a detailed diagram of the video system shown in Fig.1 including a motion tracking apparatus according to a first embodiment of the present invention. The headphone 100 includes a left ear bud 100a and a right ear bud 100b. Both ear buds 100a, 100b include a transceiver unit 110a, 110b, a RSSI-filter 120a, 120b for the received signal strength indicator and loudspeakers or audio actuators 130a, 130b. The left ear bud 100a receives via the transceiver 110a an audio signal a(t) from the console 200 and transmits via the transceiver 110a a first measurement signal $m_1(t)$ to the console 200. Both signals a(t), $m_1(t)$ are transmitted and received via a first transmission path s_1. Accordingly, the right ear bud 100b receives via the transceiver 110b the audio signal a(t) from the console 200 and transmits via the transceiver 110b a second measurement signal $m_2(t)$ to the console 200. These signals a(t), $m_2(t)$ are transmitted and

received via a second transmission path s_2.

[0037] Thus, in contrast to conventional wireless headphones, where the left and the right ear bud receive an audio signal via a common wireless transceiver unit, the ear buds 100a, 100b of the headphone 100 according to the present embodiment receive the audio signal a(t) via two autonomous wireless transceiver units 110a, 110b. The console 200 includes a transceiver 210 transmitting the audio signal a(t) to the left and right ear bud 110a, 100b and receiving the measurement signals $m_1(t)$, $m_2(t)$ from the left and right ear bud 110a, 100b and outputting the measurement data m_1[k], m_2[k]. The measurement signals $m_1(t)$, $m_2(t)$ include measurement data m_1[k], m_2[k] required for determining the position of the headset 100. Moreover, the console 200 includes a position calculator 220 receiving measurement data m_1[k], m_2[k] from the transceiver 210, a game application 240 receiving position data p[k] from the position calculator 220 and an audio encoder 230 receiving a stereo audio stream a_s[k] from the game application 240. The audio encoder 230 provides an encoded and/or modulated audio signal a(t) to the transceiver 210.

[0038] The detailed explanation of the video system shown in Figs.1 and 2 should be started at the game application 240, which provides the stereo audio stream a_s[k] to the audio encoder 230. The stereo audio stream a_s[k] depends on the game running in the game application 240. In other words, the user can influence the stereo audio stream a_s[k] by its movement measured and determined by means of the motion tracking apparatus according to the invention. The audio encoder 230 encodes stereo audio stream a_s[k] into an encoded audio signal a(t) including first audio data a_1[k] for a first audio channel and second audio data a_2[k] for a second audio channel. The audio signal a(t) is provided to the left and right ear bud 100a, 100b. Encoding schemes to be applied in the audio encoder 230 are well known for a skill person and should therefore not be explained further. The transceiver 210 prepares the audio signal a(t) for the wireless transmission to the ear buds 100a, 100b. This usually includes converting the audio stream included in the audio signal a(t) from the application layer into the physical layer according to the Open Systems Interconnection Basic Reference Model (OSI model), which is well known to a skilled person. Finally, the transceiver 210 in the console 200 transmits the audio signal a(t) to the transceivers 110a, 110b of the left and right ear bud 100a, 100b.

[0039] The transceivers in the left and right ear bud 100a, 100b now perform two tasks. In the first task, the left ear bud 100a reconstructs the encoded audio stream a[k] from a first audio signal $a_1(t)$ received via the first transmission path s_1. The right ear bud 100a reconstructs the encoded audio stream from a second audio signal $a_2(t)$ received via the second transmission path s_2. Next, the audio data a_1[k], a_2[k] are filtered from the encoded audio stream a[k] and provided to respective loudspeakers 130a, 130b in the left and right ear bud 100a, 100b for playing the audio data.

[0040] In the second task, the first and second audio signals $a_1(t)$, $a_2(t)$ are respectively provided to the RSSI-filters 120a, 120b, which now sense amplitude values A_1, A_2 of the first and second audio signal $a_1(t)$, $a_2(t)$ and include these values A_1, A_2 respectively into the measurement data m_1[k], m_2[k]. Next, the measurement data m_1[k], m_2[k] are provided back to the transceivers 110a, 110b in the left and right ear bud 100a, 100b and converted into measurement signals $m_1(t)$, $m_2(t)$ according to the same procedure as in the transceiver 210 of the console 200. Finally, the transceivers 110a, 110b in the left and right ear bud 100a, 100b transmits the measurement signals $m_1(t)$, $m_2(t)$ to the transceiver 210 in the console 200.

[0041] After receiving, the transceiver 210 in the console 200 reconstructs the measurement data m_1[k], m_2[k] from the measurement signals $m_1(t)$, $m_2(t)$ and provides it to the position calculator 220. Based on the amplitude values A_1, A_2 included in the measurement data m_1[k], m_2[k] the position calculator 220 determines the position data p[k] according a mathematical equation, which should be described later. Finally, the position data p[k] are provided to the game application 240 and the above described procedure restarts.

[0042] Thus, the RSSI-filters 120a, 120b included in the left and right ear bud 100a, 100b correspond the motion tracking apparatus according to the present invention.

[0043] Since the video gaming apparatus considers the transmission of the audio signal a(t) via the first and second transmission path s_1, s_2, the position and motion of the headset 100 can only be determined in two dimensions. This might be the distance between headset 100 and console 200, and the rotation angle β of the headset 200. However, it is possible to use further transmission paths to the headset 100 to enable the determination of the position of the headset 100 even in three dimensions.

[0044] Alternatively, it is also possible to arrange in each ear bud a data source instead of the RSSI-filters 120a, 120b, wherein each data source is adapted to transmit a unique signal to the console 200. The console 200 receive both signals and determines the measurement data m_1[k], m_2[k] based on the amplitudes of the signals derived from the data source in the head set and transmitted via the transceivers 110a, 110b.

[0045] Summarized, there is a plurality of variations to achieve the effect of the invention. It must only be assured that a signal with a predetermined characteristic is transmitted via at least two different transmission paths.

[0046] Fig. 3 is an embodiment for transceivers 110, 210 of the video gaming system shown in Fig.2. Thereafter, a transceiver 110, 210 includes an antenna 310, a first and second pre-amplifier 320, 330, at least one mixer 340, a baseband-filter 350, a modulator 360, a demodulator 370 and a processing unit 390. Further, the transceivers 110, 210 include a first to fourth communication port 390-393.

[0047] The explanation of the transceivers 110, 210 should start based on a signal received by the antenna 310. As

explained above, this signal could be the first and second audio signal $a_1(t)$, $a_2(t)$ or the measurement signals $m_1(t)$, $m_2(t)$. The received signal is amplified by the second pre-amplifier 330 and provided to the mixer 340 and the baseband unit 350. The transceivers 110, 210 also allow to output the pre-amplified received signal via the fourth communication port 393. In case of the transceiver 110a, 110b in the headset 100 this port may be connected to received signal strength indicator filters 120a, 120b for deriving the amplitude values A_1, A_2. The mixer 340 and the baseband filter unit 350 transforms the pre-amplified received signal into a baseband signal. This procedure is well known to a skilled person and should not be described in further detail. The baseband signal is now provided to the demodulator 370 demodulating the baseband signal to digital bits in the physical layer according to the OSI-model. The transceivers 110, 210 also allow to output the baseband signal via the third communication port 392. In case of the transceiver 110a, 110b in the headset 100 this port may be connected to received signal strength indicator filters 120a, 120b for deriving the amplitude values A_1, A_2. The advantage of deriving the amplitude values A_1, A_2 is that baseband signal strength indicators are less sensitive to out-of-band interferences. The digital bits according to the physical layer in the OSI-model are finally provided to the processing unit 380 transforming the bits into a data stream according to the seventh layer in the OSI-model. This data stream could be either the audio stream a[k] provided via the first communication port 390 or the measurement streams $m_1[k]$, $m_2[k]$ provided via the second communication port 391 depending in which device (headset 100 or console 200) the transceiver is implemented.

[0048]   The first and second communication ports 390, 391 are implemented bidirectional. In other words, these ports can not only output a data stream provided from the processing unit 380 but also input a data stream to be provided to the processing unit. In this case, the data stream (according to the seventh layer in the OSI-model) would be converted into a bit stream according to the first layer in the OSI-model and provided to the modulator 360. This unit would modulate the bit stream onto a high-frequency signal, which is finally pre-amplified in the first pre-amplifier 320 prior transmitting via the antenna 310.

[0049]   The transceivers 110, 210 described in Fig.3 are well known to a skilled person as near-field magnetic induction transceivers. After describing the transceivers 110, 120, an embodiment for the motion tracking apparatus according to the present invention should be explained in further detail. According to the explanations above, these are the received signal strength indicator filter 120a, 120b in Fig.2.

[0050]   Fig. 4 is an embodiment for the RSSI-filter 120a, 120b implemented in the video gaming system according to Fig.2. The RSSI-filter comprises a pre-amplifier 410, a sampling unit 420 and an analog to digital converter 430, hereinafter called ADC 430.

[0051]   The preamplifier 410 receives and amplifies the audio signal a(t) in the high frequency band or in the baseband, as described in Fig.3. The sampling unit 420 receives the pre-amplified first or second audio signal $a_1(t)$, $a_2(t)$ and samples amplitude values A_1, A_2 according to a predetermined sampling rate. The sampling rate can be chosen depending on the technical requirements of the overall video gaming system. This may be the channel capacity available between the headset 100 and the console 200, the data processing speed in the position calculation unit 220 and/or the sensitivity with which the motion of the headset 100 should be tracked. The amplitude values A_1, A_2 may be sampled as peak-to-peak values, as root-square mean values or as any other suitable value to be processed in the position calculation unit 220. However, the invention works best, if the root-square mean amplitude values of the pre-amplified first or second audio signal $a_1(t)$, $a_2(t)$ will be sampled, since these values provide the best interference immunity and therewith an optimal performance. Further, since the signal attenuation between the console 200 and the headset 100 decreased with the power of six, the best embodiment for realizing the invention is to sample the root-square mean amplitude values logarithmically, since this would provide the broadest measurement range. After sampling in the sampling unit 420, the amplitude values A_1, A_2 are fed into the ADC 430 and transformed into the measurement data $m_1[k]$, $m_2[k]$.

[0052]   The measurement data $m_1[k]$, $m_2[k]$ including amplitude values A_1, A_2 are finally transmitted to the console 200 and therein to the position calculation unit 220. The most effective transmission scheme for transmitting the measurement data $m_1[k]$, $m_2[k]$ will be time division multiplexing (TDM). In the position calculation unit 220, the position of the headset 200 is calculated based on the measurement data $m_1[k]$, $m_2[k]$ - and in detail based on the amplitude values A_1, A_2. A possible calculation scheme should be shortly discussed hereinafter.

[0053]   Fig. 5 is a diagram for explaining an exemplary calculation scheme for calculating the position of headset shown in Fig.1. This comprises the rotation angle β of the headset 100 and the distance between the headset 100 and the console 200.

[0054]   First, the rotation angle β should be defined. The rotation angle β of the headset 100 should be defined as this angle which results between an actual position and an initial position being parallel to the console 200.

[0055]   The transmission path from the left ear bud 100a to the console 200 can be described by a first distance d_a. The transmission path from the right ear bud 100a to the console 200 can be described by a second distance d_b. The distance between the left and right ear bud 100a, 100b can be described by d_{ab}, wherein d_{ab} should be constant. For all further considerations, it should be assumed, that:

$$d_a, d_b \gg d_{ab} \qquad\qquad (1)$$

The legs of the rotation angle β and the second distance d_b together form a triangle, which can be considered as being rectangular based on the simplification according to equation (1). Thus, the sinus of the rotation angle β is given as:

$$\sin(\beta)=(d_b-d_a)/d_{ab} \qquad\qquad (2)$$

[0056]   For further simplifying the calculation of the rotation angle, it should be assumed that the rotation angle β is very small. For small angles, the sinus-function could be approximated by a linear function. Thus, the rotation angles β apply:

$$\beta = (d_b-d_a)/d_{ab} \qquad\qquad (3)$$

The distance between the headset 100 and the console 200 applies as the medium value between the first and second distance d_a, d_b:

$$d=(d_a+d_b)/2.$$

[0057]   Fig. 6 is a detailed diagram of the video system shown in Fig.1 and including a motion tracking apparatus according to a second embodiment of the present invention. Therein, equal features as in the embodiment shown in Fig.2 are provided with the same reference signs and should not be mentioned in further detail hereinafter.

[0058]   Synchronously to the first embodiment, the motion tracking apparatus according to the second embodiment is distributed over the headset 100 and the console 200. However, the second embodiment includes one transceiver 250 having two different antennas for transmitting the first audio signal $a_1(t)$ and the second audio signal $a_2(t)$ independent to each other. The headset 100 includes a common transceiver 110 for receiving the first and second audio signal $a_1(t)$, $a_2(t)$ and providing the first audio data $a_1[k]$ to the right ear bud 130a and the second audio data $a_2[k]$ to the left ear bud 130b. Further, the common transceiver 110 provides the first and second audio signal $a_1(t)$, $a_2(t)$ itself to the received signal strength indicator filters 120a, 120b. These filters may be realized by different units as shown in the present embodiment or by a single unit.

[0059]   The measurement data $m_1[k]$, $m_2[k]$ may be transmitted within the different measurement signals $m_1(t)$, $m_2(t)$ back to different antennas of the transceiver 250, as shown in the present embodiment. Alternatively, the measurement data $m_1[k]$, $m_2[k]$ may be included into one single motion signal. This may have the advantage, that the motion signal can now be protected against transmission errors by antenna diversity.

[0060]   Fig. 7 is a detailed diagram of the video system shown in Fig.1 and including a motion tracking apparatus according to a third embodiment of the present invention.

[0061]   The third embodiment of the motion tracking apparatus is a combination of the first and second embodiment. Therein, the console 200 is taken from the second embodiment of the motion tracking apparatus. In contrary thereto, the headset 100a, 100b is taken from the first embodiment.

[0062]   In the present embodiment, the motion tracking apparatus is operated with four different antennas. That is, in the present embodiment, there is not only a distance between the antennas at one of the receiving side or the transmitting side of the audio signals $a_1(t)$, $a_2(t)$ but on both, the receiving side and the transmitting side. This allows to introduce one more information into the calculation of the position in space of the headset 100a, 100b. This information can be used to calculate one further position information as for example the head inclination of the user using the headset 100a, 100b. The only pre-requirement is, that the antennas on the transmitting side and the antennas on the receiving side are arranged on lines standing to each other in a skew way.

[0063]   In a further embodiment, not shown in the Figures, the motion tracking apparatus may include calibration means for correcting inaccuracies. These may occur due to misalignment of the antennas, antenna spread, gain spread, received signal strength indicator measurement spread or the like. These calibration means makes sure, that there is a defined basis for the audio signals $a_1(t)$, $a_2(t)$ based on which distortions like the above discussed damping of the audio signals $a_1(t)$, $a_2(t)$ can be detected and quantized as measurement data within the measurement data $m_1[k]$, $m_2[k]$.

[0064] The motion tracking apparatus according to the present invention is a light weight, cost effective and technically simple solution to determine the position of an object, as e.g. the distance and rotation of the object relative to a reference object. It is proposed to verify the propagation of a signal via at least two different transmission paths and to determine the position of the object according to the different characteristics of the transmission paths based on that signal. The amount of transmission paths to be considered depends on the amount of dimensions which should be considered to determine the position of the object.

Claims

1. Apparatus for sensing a position $p[k]$ of a monitor object (100) relative to a reference object (200), wherein the position $p[k]$ is provided in form of measurement data $m_1[k]$, $m_2[k]$, wherein the monitor object (100) and the reference object (200) are connected via a first and second transmission path (s_1, s_2) for signal transmission and the first and second transmission path (s_1, s_2) are at least partly spaced to each other, the apparatus (120a, 120b) adapted to

   - measure at least one characteristic of the first transmission path (s_1) and at least one characteristic of the second transmission path (s_2) based on at least one signal $a(t)$ transmitted via the first and second transmission path (s_1, s_2), and
   - generate the measurement data $m_1[k]$, $m_2[k]$ based on at least the characteristics,
   - provides the measurement data $m_1[k]$, $m_2[k]$ to a position determination means (220).

2. Apparatus according to claim 1, wherein the characteristics are a signal damping or a signal delay.

3. Apparatus according to claim 1 or 2, wherein the characteristic of the first transmission path (s_1) and the characteristic of the second transmission path (s_2) measured by the apparatus is the same or the same but at different points in time.

4. Apparatus according to one of the claims 1-3, wherein the monitor object (100) is a headset and the reference object (200) is a multimedia device providing video and/or sound depending on the position $p[k]$ of the monitor object (100).

5. Apparatus according to one of the claims 1-4, wherein the signal $a(t)$ is a media stream including audio and/or video information.

6. Apparatus according to one of the claims 1-5, further including at least a first receiver (110a) and a second receiver (110b) locally displaced to each other, wherein the first receiver (110a) is adapted to receive the signal $a(t)$ via the first transmission path (s_1) and the second receiver (110b) is adapted to receive the signal $a(t)$ via the second transmission path (s_2).

7. Apparatus according to one of the claims 1-6, which is adapted to determine at least one signal strength indicator indicating a signal amplitude of the received signal as the measurement data $m_1[k]$, $m_2[k]$ and to compare the determined signal strength indicator with a predetermined signal strength indicator, wherein the determination of the signal strength indicator includes preferably to determine a root-mean-square amplitude of the received signal.

8. Apparatus according to one of the claims 1-7, further including sending means for sending the measurement data $m_1[k]$, $m_2[k]$ back to receiving means included in the transmitting source of the signal $a(t)$ or to other receiving means for further data processing preferably for determining the position of the monitor object (100).

9. Apparatus according to one of the claims 1-8, which is adapted to receive the signal $a(t)$ via the at least first and second transmission path (s_1, s_2) and/or to send the measurement data $m_1[k]$, $m_2[k]$ based on time division multiplexing.

10. Apparatus according to one of the claims 1-9, further including means for sub-sampling, for filtering and/or compressing the measurement data $m_1[k]$, $m_2[k]$ prior sending.

11. Apparatus according to one of the claims 1-8, wherein the apparatus (120a, 120b) for motion tracking is included in the monitor object (100) and the transmitting source for transmitting the signal $a(t)$ via the at least first and second transmission path (s_1, s_2) is included in the reference object (200), wherein the position determination means (220) is included in the monitor object (100) or in the reference object (200).

12. Multimedia system for providing multimedia data in a signal a(t) on a multimedia output device (100) depending on a motion p[k] of the multimedia output device (100), the multimedia system includes:

- a multimedia transmitter (200) adapted to wirelessly transmit the signal a(t) to the multimedia output device (100);
- the multimedia output device (100) including an apparatus (120a, 120b) according to one of the claims 1-10 and adapted to wirelessly transmit the measurement data $m_1[k]$, $m_2[k]$ back to the multimedia transmitter (200) based on the signal a(t).

13. Multimedia system according to claim 12, wherein the multimedia transmitter (200) or the multimedia output device (100) are adapted to determine a relative rotation angle β of the multimedia output device (100) based on the measurement data $m_1[k]$, $m_2[k]$ and a spatial distance d_{ab} between a first and second receiver (100a, 100b) included in the multimedia output device (100).

14. Multimedia system according to claim 13, wherein the multimedia transmitter (200) is adapted to determine the length d_a of the first transmission path and the length d_b of the second transmission path, and to determine the relative rotation angle β based on the equation

$$\beta = \frac{d_a - d_b}{d_{ab}}.$$

15. Method for sensing a position p[k] of a monitor object (100) based on measurement data $m_1[k]$, $m_2[k]$ including information about the position p[k] of the monitor object (100) located relative to a reference object (200), the method comprises the steps of:

- determining a characteristic of at least a first transmission path (s_1) and a second transmission path (s_2) arranged between the monitor object (100) and the reference object (200), wherein the first and second transmission path (s_1, s_2) are located between the monitor object (100) and the reference object (200) and at least partly spaced to each other; and
- calculating measurement data $m_1[k]$, $m_2[k]$ at least based on the determined characteristics;
- calculating the position of the monitor object (100) based on the measurement data $m_1[k]$, $m_2[k]$.
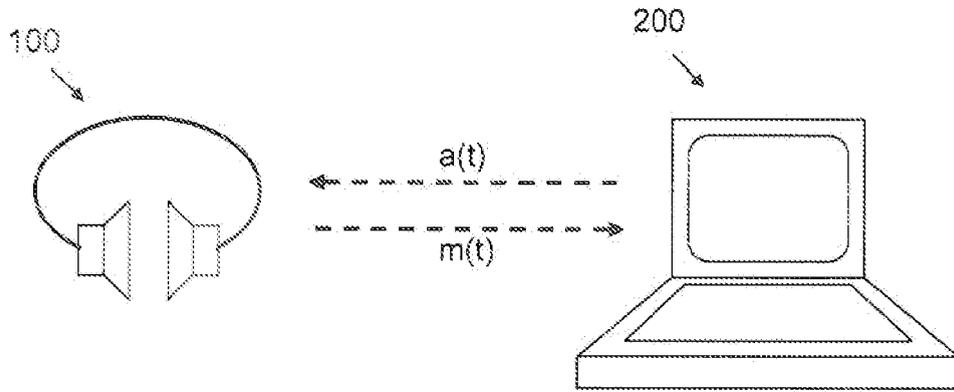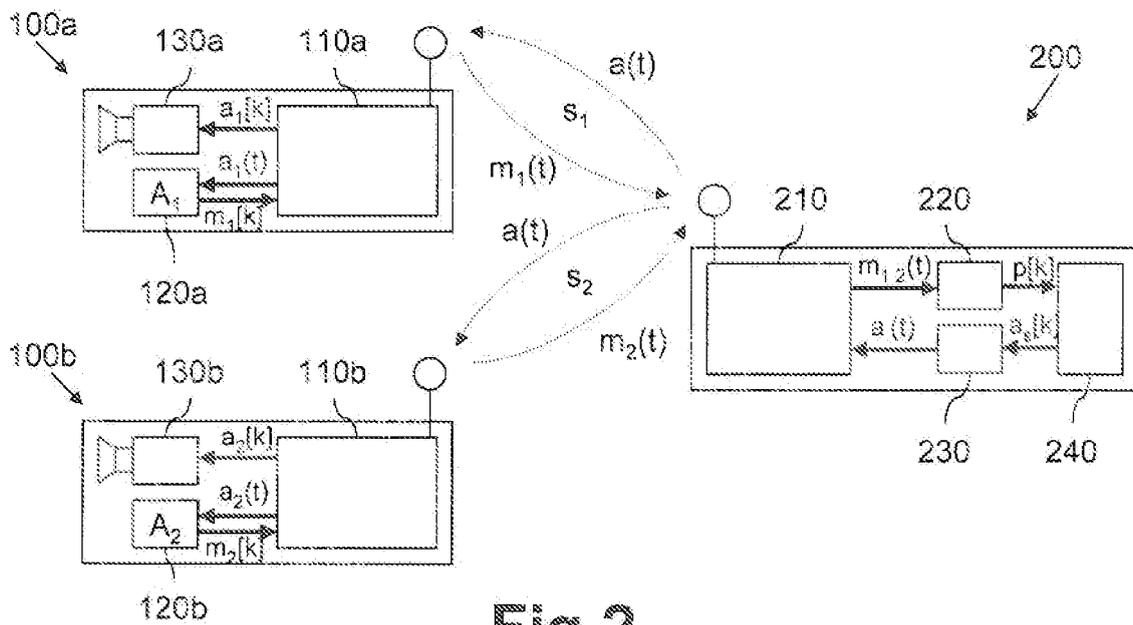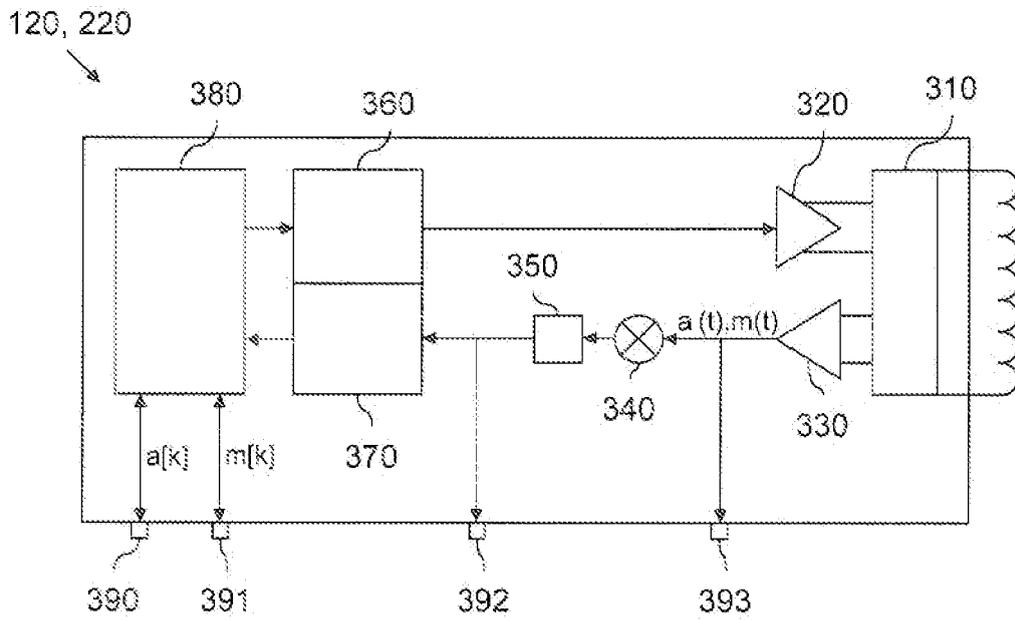
Fig.1

Fig.2

120, 220

380　　360　　　　　　　　　　320　310

350

a (t).m(t)

340

330

370

a[k]　m[k]

390　391　　　392　　　393

Fig.3

120a, 120b

410　420　430

$a_{1,2}{}^*(t)$

$a_{1,2}(t)$

m[k]

Fig.4

100b

100a

d_{ab}

β

90°

d_a

d_b

200

Fig.5

Fig.6

Fig.7

Europäisches
Patentamt

European
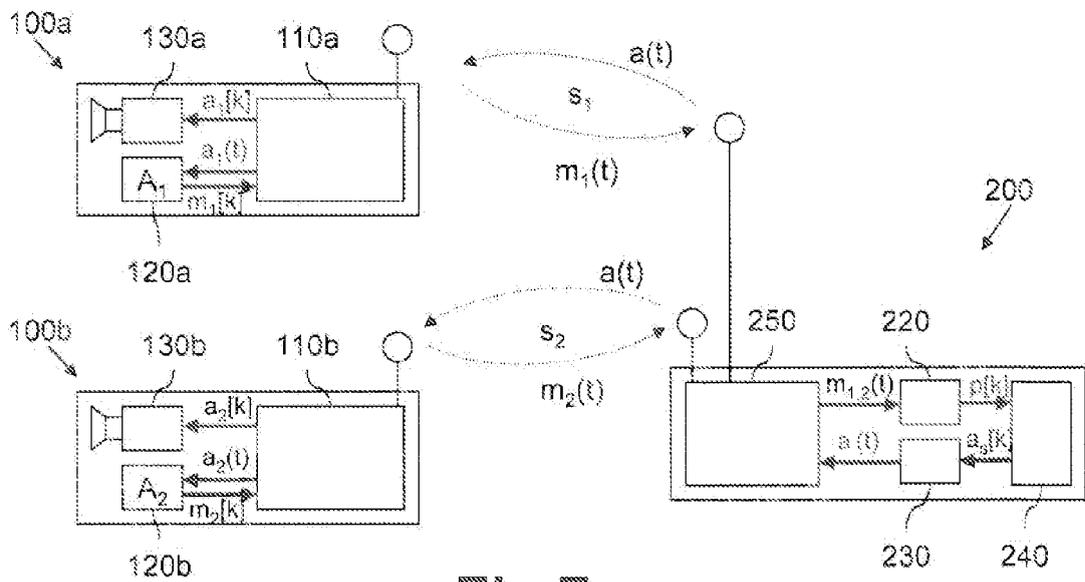Patent Office

Office européen
des brevets
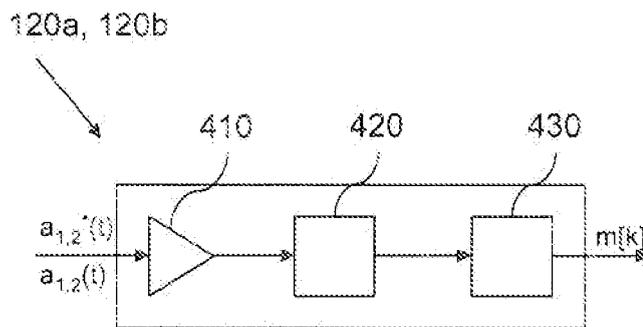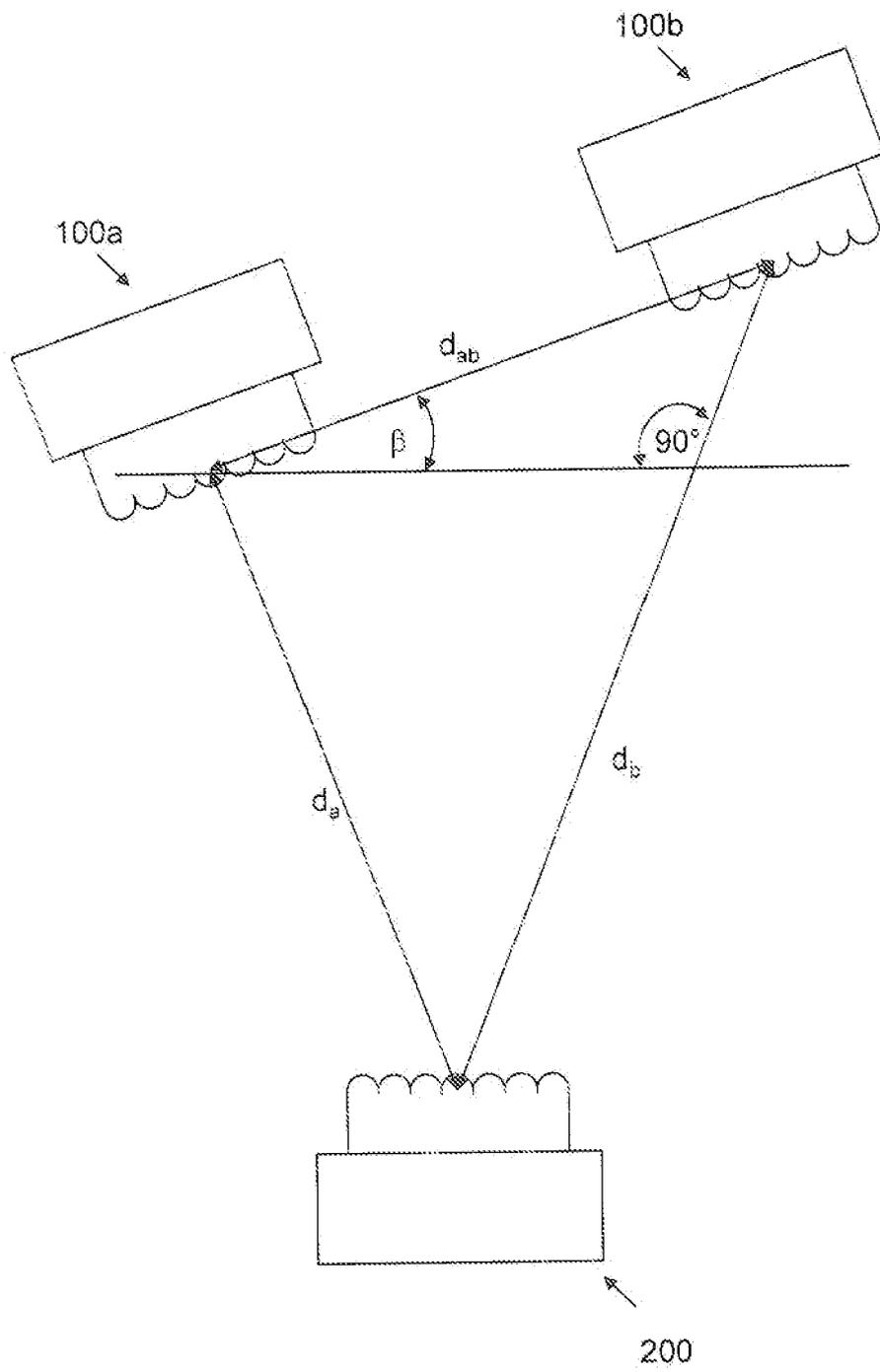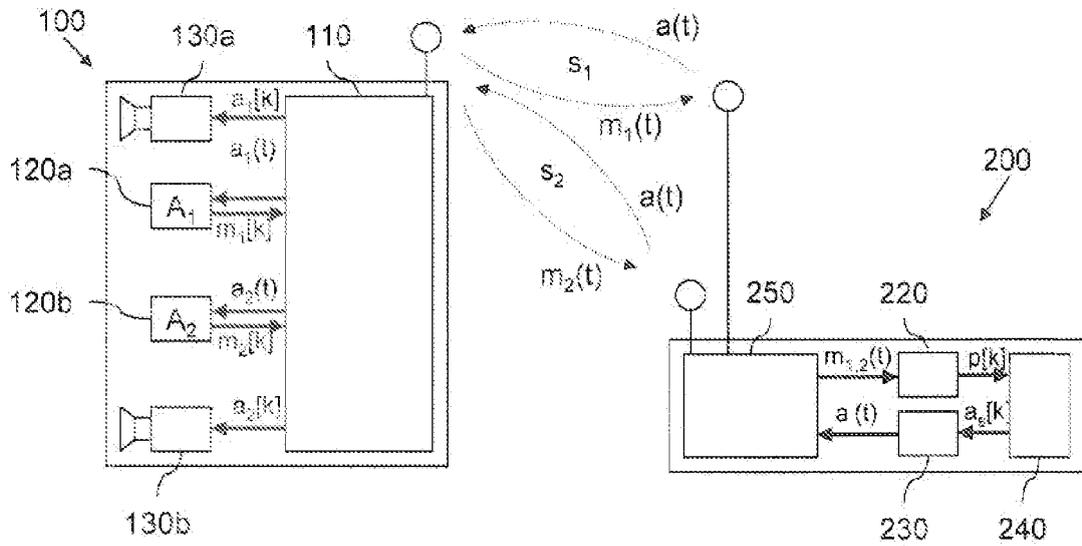
EUROPEAN SEARCH REPORT

Application Number

EP 08 15 8385

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2007/112756 A (AALBORG UNI [DK]; HAMMERSHOEI DORTHE [DK]) 11 October 2007 (2007-10-11)	1-6,8-15	INV. H04S7/00
Y	* the whole document *	7	
X	US 2004/156512 A1 (PARKER JEFFREY C [US]) 12 August 2004 (2004-08-12) * the whole document *	1-6,8-15	
Y	US 6 259 795 B1 (MCGRATH DAVID STANLEY [AU]) 10 July 2001 (2001-07-10) * column 10, line 37 - line 46 * * column 12, line 20 - line 23 * * column 12, line 54 - line 59; figures 1,10,12-14 *	7	
A	GB 2 203 315 A (ZEEVI ELIAHU IGAL) 12 October 1988 (1988-10-12) * abstract * * page 2, line 31 - page 3, line 2 *	9	

TECHNICAL FIELDS
SEARCHED (IPC)

H04S

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 October 2008	Fülöp, István

EPO FORM 1503 03.82 (P04C01)

1

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 15 8385

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-10-2008

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 2007112756	A	11-10-2007	NONE		
US 2004156512	A1	12-08-2004	NONE		
US 6259795	B1	10-07-2001	NONE		
GB 2203315	A	12-10-1988	AU	7084687 A	25-08-1987
			WO	8704799 A1	13-08-1987

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6532291 B **[0007]**