

COORDINATES DETERMINATION METHOD AND APPARATUS FOR NAVIGATION AND SITUATIONAL APPLICATIONS

Field of the Invention

[0001] The present invention generally relates to methods and apparatus of coordinates determination, and more particularly to a coordinates determination apparatus using a free rotating sphere and to methods of coordinates determination using the free rotating sphere apparatus.

Background of the Invention

[0002] Direction and location are critical for many activities including navigation, and exploration. The most conventional instrument for showing directions is the compass that functions to detect and measure the magnitude and/or direction of magnetic fields. Both mechanical and electronic compasses employ a Cartesian coordinate system to give directions on a horizontal plane. However, there are situations in which the spherical coordinates are needed to be determined. For example, a pilot shall know the spherical coordinates of his plane during the flight.

[0003] Therefore, there is an imperative need to have an apparatus and method for determining coordinates, especially the spherical coordinates. This invention satisfies this need by disclosing a free rotating sphere apparatus that can be used for coordinates determination, especially the spherical coordinates determination. Other advantages of this invention will be apparent with reference to the detailed description.

Summary of the Invention

[0004] The present invention provides an apparatus for determining coordinates, especially spherical coordinates. The coordinates determination apparatus in accordance with one embodiment of the present invention comprises an inner sphere having a first surface, a second surface and an inner space surrounded by the second surface; wherein disposed within the inner space are at least a light source 1 and a light source 2, a magnet and a weight; and a fixed shell having a first surface and a second surface; wherein the

second surface of the fixed shell is spaced from the first surface of the inner sphere to form an interspace that is filled with a liquid so that the inner sphere can freely rotate in relation to the fixed shell; wherein the first surface of the fixed shell is with grids with photo-sensitive cells so that when the inner sphere freely rotates, the coordinates can be determined at any point.

[0005] The advantages of the present invention include the readiness for computer processing provided by the free rotating sphere, the true free rotation of the sphere ensured by the use of wireless means to light up the light sources, and the determination of the direction, the yaw, pitch and roll by using a single device.

[0006] The objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0007] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0008] FIG 1 is the diagrammatic view of the free rotating sphere coordinates determination apparatus in accordance with one embodiment of the present invention.

[0009] FIG 2 shows the spherical coordinates represented by x (Pitch), y (Roll), and z (Yaw).

[0010] FIG 3 shows the vertical and horizontal grids dividing the first surface of the fixed shell in accordance with one embodiment of the present invention.

[0011] FIG 4 shows one of the eight equal sectioned spheres.

[0012] FIG 5 illustrates the concept of obtaining the deviation angle for θ and ϕ when a light position moves from one spherical coordinate to another spherical coordinate.

Detailed Description of the Invention

[0013] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0014] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0015] The present invention provides a coordinates determination apparatus as shown in FIG 1. FIG 1 is the diagrammatic view of the free rotating sphere coordinates determination apparatus in accordance with one embodiment of the present invention. It is to be appreciated that while the principles of the present invention will be illustrated by using the embodiment as shown in FIG 1, the scope of the present invention is not limited by the specific embodiment. Furthermore, for the sake of no obstruction of the invention, well-known operational procedures and component materials suitable for the present invention will not be described in detail.

[0016] Referring now to FIG 1, the coordinates determination apparatus **1** comprises a free rotating sphere **10**, a weight **11**, a magnet **12**, a light source **1 13**, a light source **2 14**, a fluid layer **20**, a fixed shell **30**, and a radio frequency (RF) source **40**. The coordinates determination apparatus further comprises a digital processor that is not shown. As discussed later, the digital processor will be responsible for receiving signals from the fixed shell **30** and determining the coordinates. The digital processor suitable for the present invention may be any product that can receive the signals and perform the determination. For example, PC, PDA, and notebook may be used as the digital processor for the present invention.

[0017] The free rotating sphere **10** has a first surface and a second surface, wherein the first surface faces the fluid layer **20**, and the second surface forms an inner space. The weight **11** may be made of any metal or other heavy materials. It will be disposed within the inner space formed by the second surface of the free rotating sphere. The weight **11** is preferably located at the bottom of the inner space. The size or dimension of the weight **11** is not critical for the present invention. As long as it can provide enough weight to maintain the free rotating sphere **10** in its position while allowing the free rotating sphere to freely rotate to provide relative movement to the fixed shell **30**, the weight **11** is applicable for the present invention. The light source **1 13** will be disposed at the top of the inner space in opposite to the weight **11**.

[0018] The magnet **12** is preferably disposed in the origin of the inner space formed by the second surface of the free rotating sphere. The magnet is preferably in a fixed position so that the free rotating sphere **10** has to rotate to enable the magnet **12** to point to the north at all times. The light source **2 14** will be disposed within the inner space at the position to which the magnet points. One of the preferred configurations is that the weight **11**, the magnet **12**, the light source **1 13**, and the light source **2 14** are disposed at one plane within the inner space formed by the second surface of the free rotating sphere

[0019] The free rotating sphere **10** may be made of any materials that are penetrable by the RF signals and with insignificant interference to the lights emitted by the light sources. In one embodiment, the free rotating sphere **10** is made of plastic. Moreover, the free rotating sphere **10** may be manufactured in many different ways. In one embodiment, the free rotating sphere may be constructed with two hemispheres. The middle of the hemisphere can be made hollow with compartments to house the weight, the magnet, the light sources and other optional components. The light sources may be constructed by using LEDs linked to antennas via electronic components such as capacitors, inductors, resistors and transistors. The technology of powering LEDs by using RF signals is well known so that there is no detailed description of the light sources. After the associated components are placed and secured inside the inner space, the two hemispheres may be glued and combined into one sphere.

[0020] The fixed shell **30** has a first surface and a second surface, wherein the first surface is facing the outside and the second surface facing the free rotating sphere. The fixed shell **30** is disposed in distance from the free rotating sphere **10**. The distance cannot be too far, else the response time will be long and the error will be significant. The gap between the fixed shell and the free rotating sphere is filled with fluid to form the fluid layer **20**. The fluid layer may comprise any liquid with certain viscosity that allows the free rotating sphere to freely rotate in relation to the fixed shell. In addition, the fluid used in the present invention shall not interfere with the transmission of lights from the light sources to the fixed shell and also allow the RF energy to pass through.

[0021] The fixed shell **30** may be made of any materials that are penetrable by the RF signals and with insignificant interference to the lights emitted by the light sources. In one embodiment, the fixed shell **30** is made of plastic. Like the free rotating sphere, the

fixed shell may be constructed with two hemispheres. In one embodiment, after the two hemispheres are glued subsequently to form the fixed shell, a hole can be provided on this fixed shell for filling in the liquid. The hole will be sealed eventually. The first surface of the fixed shell will be disposed a photo-sensitive layer. Photo-sensitive materials are well known to those skilled in the art. Any photo-sensitive material compatible with the light sources is applicable for the present invention.

[0022] The RF source **40** provides the power to light up the two light sources. This allows the free rotating sphere to be truly free rotating, while the two light sources shine on the photo sensitive cells to provide the digital information for computer processing. It does away with the necessity of wires to tap the signals which will hinder the free rotation of the sphere, hence it is able to provide coordinate information in all dimensions. The RF source will be radiating RF energy towards the Sphere. The energy from the RF source will be received by the antennae of the light sources wirelessly. This RF energy will be converted to electrical energy and used to light up the light sources. The RF technology is well known to those skilled in the art. Thus, no further description about the employment of RF sources to power up the light sources is provided herein.

[0023] Now provided is a more detailed description of the method of using the free rotating sphere coordinates apparatus to determine the spherical coordinates. As shown in FIG 2, the spherical coordinates are represented by x (Pitch), y (Roll), and z (Yaw). The weight **11** allows the free rotating sphere **10** to be always in a stable equilibrium state so that the light source 1 **13** is shining upwards and it acts as a reference for vertical plane (Yaw). The magnet and the light source 2 **14** provide reference for the horizontal plane (Pitch and Roll).

[0024] As described above, the fixed shell **30** is coated with photo-sensitive material to receive the light signals from the light sources. The fixed shell **30** is divided into grids described hereinafter. By monitoring of the light-activated grids, the coordinates and the directions of movement can be derived.

[0025] The spherical coordinates can be derived from the light beams of the two light sources shone on the photo-sensitive material. The light source 1 **13** is taking reference of the vertical axis (z-axis). The light source 2 **14** is taking reference of the north direction. The degree of deviation of these references can be used to calculate the spherical coordinates.

[0026] As shown in FIG 3, in one embodiment, the first surface of the fixed shell 30 is divided into vertical and horizontal grids. The grids may be made of lines of conductors arranged in the manner similar to longitude and latitude on the globe. The grids are partitioned into eight equal sectioned spheres to ensure independency in signal read out. The photo-sensitive cells are placed within the intersections of the lines of the grids. At each intersection of the grids, a photo-sensitive device is placed there. The photo-sensitive device may be connected to a digital processor (e.g., micro-P or DSP) pin. When the light emitted from the light sources hits a particular photo-sensitive cell, the corresponding “longitude” and “latitude” information of the cell will be sensed by the digital processor. The digital processor will then calculate the direction and spherical coordinates of the object.

[0027] By looking at the intersection of the grid that it is located at, the coordinates can be obtained and expressed as a function of r , θ and ϕ . The r is the radius of the sphere, θ the deviation angle from the z axis and ϕ is the deviation angle from the x axis. The light source 1 13 gives light position 1, which is a function of r_1 , θ_1 and ϕ_1 . Similarly, the light source 2 14 gives light position 2 and can be characterized by r_2 , θ_2 and ϕ_2 .

$$\text{Light Position 1} = \text{fn}(r_1, \theta_1, \phi_1) \quad (1)$$

$$\text{Light Position 2} = \text{fn}(r_2, \theta_2, \phi_2) \quad (2)$$

[0028] If r_1 and r_2 are constants, θ_1 , ϕ_1 , θ_2 and ϕ_2 can be used to determine the yaw, pitch, roll and direction. For example, if there is a rotation about the x axis, there will be no movement to light position 2 and $\theta_2 = 0$ and $\phi_2 = 0$. For light source 1, $\phi_1 = 0$ and the θ_1 will give the deviation in pitch.

[0029] FIG 4 shows one of the eight equal sectioned spheres. It has been arranged in different configuration as compared to FIG 3. FIG 3 shows that the photo sensitive cells are being located in an equally spaced manner from one another. In FIG 4 the density of the photo sensitive cells is higher towards the upper and lower poles as the space between cells gets closer. They are presented as different configurations that the photo sensitive cells can be arranged. FIG 5 shows the grids of FIG 3 or FIG 4 (3-Dimension) on a planar view (2-Dimension). FIG 5 is used to illustrate the concept of obtaining the deviation angle for θ and ϕ when a light position moves from one spherical coordinate to another spherical coordinate. For example, if the light position moves from (a,1) to (e,3), the deviation angles can be calculated accordingly. In this example, the light moves 4 steps

horizontally (from “a” to “e”) and 2 steps vertically (from “1” to “3”). After calibration, angle change per step can be known accordingly. Then the total angular changes in both horizontal and vertical directions can be determined.

[0030] The applications of the coordinates determination apparatus of the present invention may include navigation system where the information about yaw, pitch, roll and direction are important; robot navigating and balancing; and wall tilting (angle measurement with respect to horizontal).

[0031] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. An apparatus for coordinates determination, comprising:
an inner sphere having a first surface, a second surface and an inner space surrounded by the second surface; wherein disposed within the inner space are at least a light source 1 and a light source 2, a magnet and a weight; and
a fixed shell having a first surface and a second surface; wherein the second surface of the fixed shell is spaced from the first surface of the inner sphere to form an interspace that is filled with a liquid so that the inner sphere can freely rotate in relation to the fixed shell;
wherein the first surface of the fixed shell is with grids with photo-sensitive cells so that when the inner sphere freely rotates, the coordinates can be determined at any point.
2. The apparatus of claim 1, further comprises a radio frequency source that provides energy for the light sources so that the light sources can be powered up wirelessly.
3. The apparatus of claim 2, wherein the light sources comprises a LED emitting the lights, an antenna receiving energy from the RF source, and an electronic circuit for converting the RF energy from the antenna into electric energy for being used by the LED.
4. The apparatus of claim 1, further comprises a digital processor that receives the signal from photo-sensitive devices disposed at the intersections of the grids on the first surface of the fixed shell so that the coordinates can be determined.
5. The apparatus of claim 4, wherein the photo-sensitive devices are connected directly or indirectly to the digital processor pins.
6. A method for determining the coordinates by employing the apparatus of claim 1, said method comprising the following steps of:

powering up the lights sources so that the light sources will emit lights to hit the photo-sensitive cells;

receiving the location information of the light-hit photo-sensitive cells disposed at the intersections of the grids by a digital processor device; and

determining the coordinates.

7. The method of claim 6, wherein the coordinates are determined by the following steps of:

calibrating the angular change per step when the light moves horizontally or vertically;

calculating the horizontal change steps and vertical change steps when the light moves from one position to another position on the grids of the fixed shell; and

calculating the spherical coordinates of the new position based on the angular changes in both horizontal and vertical directions.