

APPARATUS AND METHOD FOR NAVIGATION

BACKGROUND OF THE INVENTION

[001] Simple and accurate geo-positioning based on solar movements have long been a goal of navigational instruments. Similarly, fast and dependable fixes of 'true north' while in some cases available from GPS, remains a tedious and time consuming chore for engineering, military, land surveying, airborne, sports and maritime uses. Detection of solar radiation and atmospheric conditions have long been the goal of climate forecast and green energy industries. Similarly, fast and low cost measurement of solar radiation and atmospheric particles, while in some cases can be provided by, for example, an active laser instrument, remains an expensive and time-consuming chore for climatology and green energy engineering.

SUMMARY OF THE INVENTION

[002] Embodiments of the present invention may provide an apparatus, the apparatus may include: an array of polarized light filter cells, each cell may include a first polarized filter having a first polarization direction and a second polarized filter having a second polarization direction, said second polarization direction different from said first polarization direction. The second polarization direction may be substantially perpendicular to said first polarization direction. The filter cells may be arranged in co-centered rings.

[003] The apparatus may further include an optical system to direct light onto said array of polarized light filters; and a first light sensor to produce data from light received through said first polarized filter and a second light sensor to produce data from light received through said second polarized filter. The first and second light sensors may be comprised in an array of light sensors, having at least one light sensor juxtaposed to each polarized filter.

[004] According to some embodiments, the apparatus may further comprise a processing unit to derive polarization pattern based on said data. The processing unit may be for calculating at least one of intensity and direction of polarization by measuring a difference between a light intensity received through said first polarized filter and a light intensity received through said second polarized filter and for deriving said polarization pattern

based on said calculations. The processing unit may be for calculating location data of a celestial body based on said polarization pattern, for example, at least one of azimuth and elevation of the celestial body. The processing unit may be for calculating navigational data based on said location data of a celestial body. The processing unit may calculate
5 navigational data further based on complementary data stored in a memory

[005] An apparatus according to some embodiments of the present invention may further include a wavelength separator to separate at least one wavelength band from light directed by said optical system. A processor unit in the apparatus may calculate a pattern of polarized light in at least one wavelength band separated by the wavelength separator. The
10 wavelength separator may include an array of color filters arranged in groups of at least one color filter, each group being juxtaposed to a polarized filter.

[006] According to some embodiments of the present invention, the apparatus may include a memory for storing complementary data of at least one of a list comprising a sun path table, an astronomical chart, a calendar chart, an ephemeris table, a time standard, a
15 skylight polarization chart, a calibrated chart of true north, magnetic north and grid north.

[007] Further according to some embodiments of the present inventions, the apparatus may comprise an inclinometer for detecting the inclination of said apparatus.

[008] Additionally, embodiments of the present invention may provide a method, the method may include: directing light onto an array of polarized light filter cells, each cell
20 may include a first polarized filter having a first polarization direction and a second polarized filter having a second polarization direction different from said first polarization direction. The second polarization direction substantially perpendicular to said first polarization direction.

[009] The method may further include producing data from light received through said
25 first polarized filter by a first light sensor and through said second polarized filter by a second light sensor; and deriving polarization pattern based on said data.

[0010] According to some embodiments, the method may further include calculating at least one of intensity and direction of polarization by measuring the difference between the light intensity received through said first polarized filter and the light intensity received
30 through said second polarized filter and creating said polarization pattern based on said calculations.

[0011] According to some embodiments of the present invention, the method may further include separating at least one wavelength band from said directed light. The calculation of a pattern of polarized light may be in at least one separated wavelength band.

5 [0012] According to some embodiments of the present invention, the method may further include detecting the inclination of said apparatus.

[0013] According to some embodiments of the present invention, the method may further include calculating location data of a celestial body based on said polarization pattern. The location data may include at least one of azimuth and elevation of said celestial body.

10 [0014] According to some embodiments of the present invention, the method may further include calculating navigational data based on said location data of a celestial body. In some embodiment of the present invention, the calculation of navigational data may further be based on complementary data stored in a memory.

BRIEF DESCRIPTION OF THE DRAWINGS

15 [0015] The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features, and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

20 [0016] Fig. 1 is a cross-sectional schematic illustration of an apparatus for navigation according to some embodiments of the present invention;

[0017] Fig. 2 is a schematic illustration of an exemplary polarizer according to some embodiments of the present invention;

[0018] Fig. 3 is a partial schematic illustration of a polarization detection unit apparatus according to some embodiments of the present invention;

25 [0019] Figs. 4A and 4B are schematic illustrations of polarization patterns which may be derived by a processing unit according to some embodiments of the present invention; and

[0020] Fig. 5 is a schematic flowchart illustrating a method for navigation according to some embodiments of the present invention.

30 [0021] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further,

where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0022] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0023] Reference is now made to Fig. 1, which is a cross-sectional schematic illustration of an apparatus 10 for navigation according to some embodiments of the present invention. Apparatus 10 may include an optical system 110, a polarizer 120, a light sensor 220 and a processing unit 200.

[0024] Optical system 110 may direct and/or focus light rays onto polarizer 120. Optical system 110 may include single or multiple optical elements such as, for example, a lens, a lenslet array, micro-lenses, pinhole, fiber optics, waveguides, or other suitable optical elements. In some embodiments, apparatus 10 may additionally include optical zoom, moving optical elements and/or focus systems.

[0025] Polarizer 120 may include an array of polarized light filters (shown in Fig. 2). Polarizer 120 may pass light components which are linearly polarized in a direction complying with the design of polarizer 120 and block substantially all or other angles of polarized light. The polarized light which passes through polarizer 120 may create a pattern of polarization intensity and/or direction of the absorbed light which may be reflected onto light sensor 220. For the purposes of this specification, the term "pattern" may include, but not limited to, a vector of values, a map of scales, or any other conventional meaning of the term "pattern".

[0026] When optical system 110 directs and/or focuses onto polarizer 120 skylight (i.e. the radiation originated in a celestial body such as the sun and reflected and/or scattered by the atmosphere towards earth) or earthlight (i.e. the reflected and/or scattered skylight from earth), the pattern of polarization may enable obtaining navigational data by apparatus 10.

[0027] Light sensor 220 may include, for example, an image sensor. Light sensor 220 may include an array of light sensor cells that convert an optical signal to an electrical signal,

such as, for example, an array of Avalanche Photodiodes (APD), a charge-coupled device (CCD), a complementary metal-oxide-semiconductor (CMOS), an active-pixel sensor (APS) or other suitable light sensor. Light sensor 220 may produce data, for example, image data or other data related to the received light, and transmit the data to processing unit 200, which may record, analyze, process, store, compress, transmit, reconstruct, convert and/or derive data based on the produced data. In some embodiments, the produced data may not include an image, but may be limited to for example data about light intensity, a direction of polarized light intensities or other limited information that may be insufficient to create an image.

[0028] Polarizer 120 may include for example two or more kinds of polarization filters (such as those shown in Fig. 3) having corresponding two different polarization directions, for example, substantially perpendicular to each other or at other discernable angles. The polarized light which passes through polarizer 120 may create a pattern of polarization intensity and/or direction of the light projected onto light sensor 220. Based on the data produced by light sensor 220, processing unit 200 may calculate direction and/or intensity of the polarization of polarized light absorbed by different areas on light sensor 220. For example, processing unit 200 may calculate direction and/or intensity of the polarization by measuring the difference between the light intensities received through the two different kinds of polarization filters by respective two or more different areas on light sensor 220, thus, for example, deriving the polarization pattern. Based on the polarization pattern, processing unit 200 may obtain navigational data such as, for example, time, true-north, location, directional and/or other useful data. Processing unit 200 may obtain the navigational data, for example, by determining location of a celestial body such as the sun, stars or moon, for example, based on one or more derived polarization patterns.

[0029] In some embodiments, apparatus 10 may be directed so that optical system 110 may direct and/or focus skylight onto polarizer 120. Apparatus 10 may be installed on a directable platform such as, for example, a watch, a helmet, sun glasses, a handheld device, a vehicle, mapping and/or surveying equipment, communication and/or timekeeping hardware, or any other suitable platform. Optical system 110 may be directed towards the zenith, for example, in order to direct and/or focus full view of the sky onto polarizer 120, and/or in order to facilitate obtaining of location and navigational data.

Alternatively, for example in cases of airborne uses, optical system 110 may be directed towards the nadir below and/or above the airborne platform and thus, for example, directing and/or focusing onto polarizer 120 reflection and/or scattering of skylight from ground. Additionally or alternatively, in some exemplary embodiments apparatus 10 may include a sensor module 240, which may include at least one orientation sensor such as, for example, global positioning system (GPS), inertial measurement unit (IMU), accelerometer, gyrometer, inclinometer, magnetic compass, altimeter, velocimeter or any other suitable sensor, in order to establish the orientation in space of apparatus 10 and/or motion information such as acceleration, velocity and/or distance of travel in space of apparatus 10. The establishment of orientation may include bearings in 6 degrees of freedom. In other embodiments, external orientation sensors such as mechanical, electronical, optical and/or visual odometer sensors may be used, for example, when apparatus 10 spins on a shaft encoder with its rotation axis aligned with the zenith-nadir vector while attached to a moving vehicle. Processing unit 200 may use the sensed orientation and/or motion information of apparatus 10 in order to compensate for the orientation of apparatus 10 in space, when calculating navigational data based on data received from light sensor 220. For example, in case the inclination of apparatus 10 deviates from being directed to the zenith or nadir, processing unit 200 may compensate for the deviated inclination when calculating location of a celestial body and/or when processing dead reckoning calculation, i.e. estimating current location based upon a previously determined location.

[0030] In some embodiments, apparatus 10 may be used underwater, for example by receiving skylight underwater and analyzing polarization pattern of skylight as discussed in detail above.

[0031] In addition to data received from light sensor 220, processing unit 200 may use complementary data to calculate the navigational data. The complementary data may include navigational and/or astronomical data, such as, for example, sun path tables, astronomical charts, calendar charts, ephemeris tables, time standards, skylight polarization charts, calibrated charts of true north, magnetic north and grid north, and/or any other data which may facilitate calculation of navigational data by processing unit 200. The complementary data may be received by processing unit 200, for example, from sources

external to apparatus 10. Additionally or alternatively, processing unit 200 may receive the complementary data from an internal memory and/or from a memory which may be included in or otherwise associated with apparatus 10, which may store the complementary data.

5 [0032] Processing unit 200 may determine location of a celestial body such as the sun, stars or moon based on derived polarization pattern of skylight or earthlight. For example, processing unit 200 may determine the location of the celestial body in any celestial coordinates such as, for example, azimuth and/or elevation of the celestial body, for example the sun or moon, based on the derived polarization pattern. Processing unit 200
10 may deduce, for example, the true north, by combining the determined location of the celestial body with path tables of the celestial body and date and/or time data. The date and time data may be received by processing unit 200 from a source external to apparatus 10 or from sensor module 240, which may also include a timekeeping device such as, for example, a clock, a real time computer clock, clock oscillators and/or mechanical,
15 electronic, optics and/or atomics chronometers. . The path tables of the celestial body may include, for example, the daily path of the celestial body, e.g., the elevation and azimuth of the sun during the day, in different times of the year and global locations.

[0033] Based on the path tables of celestial body, date information and the location of celestial body determined by processing unit 200, processing unit 200 may calculate the
20 global position of apparatus 10. Alternatively, processing unit 200 may receive global position data of apparatus 10, for example, from a global positioning system, a user interface and/or via a communication link external or internal to apparatus 10. Based on the global position data, path tables of celestial body and the location of celestial body determined by processing unit 200, processing unit 200 may deduce the time of the year,
25 e.g. date information, for example in case processing unit 200 does not receive or obtain the date information from other sources.

[0034] Additionally or alternatively, processing unit 200 may obtain a timeline of the celestial body locations, for example, by accumulating the determined locations of a celestial body during at least a certain period of time. Based on the obtained timeline,
30 processing unit 200 may deduce an approximated path of the celestial body, which may be

used by processing unit for determination of time, date, real north and/or global position of apparatus 10.

[0035] In some embodiments of the present invention, apparatus 10 may include a wavelength separator 130. Wavelength separator 130 may separate one or more wavelength bands from the polarized light. Therefore, the polarized light which passes through polarizer 120 and wavelength separator 130 may create a pattern of polarization intensity and/or direction for a certain wavelength band or for several wavelength bands, and such pattern may be projected onto light sensor 220. Wavelength separator 130 may include, for example, a color filter array such as, for example, a Bayer filter. Additionally or alternatively, wavelength separator 130 may include a trichroic beam splitter prism, bandpass and/or longpass and/or edgepass colored filters, dielectric mirrors, and/or any suitable wavelength separator. Although the example of Fig. 1 shows wavelength separator 130 between polarizer 120 and light sensor 220, other embodiments of the present invention may include other configurations, for example, so that polarizer 120 may receive the filtered light that passed through wavelength separator 130, on which the light may be directed and/or focused by optical system 110.

[0036] Different wavelength bands, which may be separated by wavelength separator 130, may be used by processing unit 200 for obtaining information such as atmospheric conditions, pollution levels, cloud densities, humidity, etc. Processing unit 200 may compare the different kinds of information and/or, for example, eliminate and/or measure the effect of pollution, clouds, humidity and/or other phenomena on the polarization pattern, for example in order to obtain more accurate navigational data based on the detected polarization pattern. For example, the polarization pattern of clear skies may be best viewed in the wavelength band around 450 nm, i.e. in the blue and violet colors. However, large particles which may be typical for pollution or clouds may scatter, and therefore be polarized, at the red and near infra red wavelength band, i.e. around 650 nm.

[0037] Apparatus 10 may be powered by an internal or external power source (not shown), such as for example, a battery, solar cells and/or other suitable power source. Additionally, apparatus 10 may include at least one antenna and/or wired and/or wireless circuitry (not shown), for example, in order to receive power and/or information from external power sources, data links, data bases and/or additional sensors and devices.

[0038] Reference is now made to Fig. 2, a schematic illustration of an exemplary polarizer 120 according to some embodiments of the present invention. Polarizer 120 may include an array of polarized light filter cells 121. Each cell 121 may include at least two polarized filters 125 and 126, having respective different directions of polarization, for example, substantially perpendicular to each other. Polarized filter cells 121 may be arranged in co-centered rings 122, for example in a disk shape. Other shapes and configurations may be used. One or more of polarized filters 125 and 126 may be juxtaposed to at least one light sensor cell in an array of light sensor cells which may constitute light sensor 220 described above with reference to Fig. 1. Thus, light sensor 220 may produce data from light received through polarized filters 125 and 126 in each cell 121. Cells 121 may be identical to each other or may include variations in the angles of filters 125 and 126. Higher number of cells 121 in polarizer 120 may enable higher imaging resolution by light sensor 220, limited by the maximal resolution of light sensor 220. The number of cells 121 in polarizer 120 may be determined by the dimensions of cells 121 and/or the number of rings 122. Additionally, the location of cells 121 may be shifted in each ring 122 relative to cells 121 in other rings 122, for example in a measure 129, which may enhance the imaging resolution of the polarization pattern by light sensor 220. .

[0039] In some embodiments of the present invention polarizer 120 may include optical retardation plates and/or depolarizers such as: Cornu depolarizer, Lyot depolarizer, Wedge depolarizer and/or other suitable depolarizer, for example on at least a portion of polarizer disc 120. Additionally or alternatively, in some embodiments, polarizer 120 may include active and/or passive optical elements such as wave plates, retarders, quarter-wave plate, half-wave plate, Faraday rotator, liquid crystals (LCs) and/or fiber optics or any other suitable element which may be used to increase the imaging resolution of the light polarization pattern. Other embodiments of the present invention may include other configurations, for example, so that polarizer 120 may receive the filtered light that passed through a wave plate, on which the light may be directed and/or focused by optical system 110.

[0040] In order to derive the polarization pattern of the light, processing unit 200 may calculate intensity and/or direction of polarization of light received through each cell 121,

for example by measuring a difference between light intensities received through polarized filters 125 and 126 in each cell 121.

[0041] Reference is now made to Fig. 3, which is a partial schematic illustration of a polarization detection element 300 of apparatus 10 according to some embodiments of the present invention. Polarization detection unit 300 may include a cell 121 including polarized filters 125 and 126, color filter arrays 135 which may be included in wavelength separator 130 and light sensor cells 225 which may be included in light sensor 220. Color filter arrays 135 may be identical to each other. Each of color filter arrays 135 may include several color filters 137, for example four color filters 137 including color filters of at least three different colors, such as, for example, a Bayer filter. In other embodiments, color filter arrays may include another number of color filters 137 and/or another number of or different colors. Color filter arrays 135 may be juxtaposed to one of polarized filters 125 and 126. Light sensor 220 may include at least one light sensor cell 225 for each color filter 137. Thus, for example, each sensor cell 225 may absorb polarized light in a particular direction, intensity and wavelength.

[0042] Therefore, for example, processing unit 200 may calculate separately for each wavelength separated by wavelength separator 130 the intensity and/or direction of polarization of the absorbed light, and may use the data as described in detail with reference to Fig. 1.

[0043] Reference is now made to Figs. 4A and 4B, which are schematic illustrations of polarization patterns which may be derived by processing unit 200 according to some embodiments of the present invention. Arrows 410 illustrate the e-vectors of the light, i.e. direction and intensity of the polarization of light derived by processing unit 200, wherein the length and width of arrows 410 is respective to intensity of the linear polarization and the direction of arrows 410 is respective to the direction of linear polarization. In this exemplary embodiment, the center of light sensor 220 is aligned with the zenith 450, and a field of view of 180 degrees is captured by light sensor 220. Fig. 4A shows the polarization pattern derived by processing unit 200 at dawn, when the sun's elevation 480 is below the horizon and the sun's azimuth 490 is directed to the west. Fig. 4B shows the polarization pattern derived by processing unit 200 at solar noon, when the sun's elevation 480 is the

highest in the sky nearest the zenith 450 during the day and the sun's azimuth 490 is directed to the south.

[0044] Azimuth line 490 of the sun may be deduced by processing unit 200, for example, by finding a line pivoted at the zenith 450 which passes through all atmospheric evaluation rings 430 and perpendicular to all e-vectors it passes through. As a result the azimuth line 490 is perpendicular to and halves the e-vector having the highest intensity. Therefore, processing unit 200 may find the e-vector having the highest intensity along azimuth line 290.

[0045] Elevation 480 may be deduced by processing unit 200, for example, by measuring the distance between the zenith 450 and the middle point of the e-vector having the highest intensity. As mentioned above, both points are located on azimuth line 490. Alternatively, in case the sun is within field of view of apparatus 10, elevation 480 may be deduced from the detection of direct sun rays. Other embodiments of the present invention may include additional e-vector representations, for example, so that the processing unit 200 may deduce the polarization information using Stokes parameters description and/or any related atmospheric and general scattering theories.

[0046] Reference is now made to Fig. 5, which is a schematic flowchart illustrating a method for navigation according to some embodiments of the present invention. As indicated in block 510, the method may include directing light onto an array of polarized light filter cells 121. As described in detail above, light filter cell 121 may comprises a first polarized filter 125 having a first polarization direction and a second polarized filter 126 having a second polarization direction different from the first polarization direction. For example, the polarization directions of filters 125 and 126 may be substantially perpendicular to each other. As indicated in block 520, the method may include producing data from light received through polarized filters 125 and 126. As indicated in block 530, the method may include deriving polarization pattern based on the produced data. The deriving of the polarization pattern may be performed by calculating at least one of intensity and direction of polarization by measuring the difference between the light intensity received through polarized filters 125 and 126. Based on the derived polarization pattern, for example by using theory of skylight scattering, location data of a celestial body may be calculated, such as, for example, azimuth and/or elevation of the celestial body.

Based on the calculated location data of a celestial body navigational data may be calculated, optionally by using also complementary data stored in a memory, as described in detail above.

[0047] According to some embodiments, the method may further include separating at least one wavelength band from the directed light, for example, in order to deduce information from the different wavelength bands as described in detail above. Therefore, the pattern of polarized light may be calculated in at least one of the separated wavelength bands.

[0048] Additionally, according to some embodiments of the present invention the method may include detecting inclination and/or motion of apparatus 10, thus, for example, enabling compensation for deviated inclination of apparatus 10 when calculating location of a celestial body. In some embodiments, a device may be moved along for example one or more axis, such as for example one of six degree of freedom with a reference to celestial system, and a calculation may be made of the movement of the device relative to the celestial body. For example, apparatus 10 may be attached to a moving vehicle and the direction, movement or position of the vehicle may be derived by comparing changes in polarization patterns at various times while the vehicle is in motion.

[0049] While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents will now occur to those of ordinary skill in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS

What is claimed is:

1. An apparatus, the apparatus comprising:

an array of polarized light filter cells, each cell comprises a first polarized filter
5 having a first polarization direction and a second polarized filter having a
second polarization direction, said second polarization direction different
from said first polarization direction;

an optical system to direct light onto said array of polarized light filters; and

a first light sensor to produce data from light received through said first polarized
10 filter and a second light sensor to produce data from light received through
said second polarized filter.

2. An apparatus according to claim 1, further comprising a processing unit to derive
polarization pattern based on said data.

3. An apparatus according to claim 1, wherein said second polarization direction is
15 substantially perpendicular to said first polarization direction.

4. An apparatus according to claim 2, wherein said processing unit is for calculating at
least one of intensity and direction of polarization by measuring a difference between a
light intensity received through said first polarized filter and a light intensity received
through said second polarized filter and for deriving said polarization pattern based on
20 said calculations.

5. An apparatus according to claim 1, further comprising a wavelength separator to
separate at least one wavelength band from light directed by said optical system.

6. An apparatus according to claim 5, , further comprising a processing unit for
calculating a pattern of polarized light in at least one wavelength band separated by said
25 wavelength separator.

7. An apparatus according to claim 5, wherein said wavelength separator comprises an
array of color filters arranged in groups of at least one color filter, each group being
juxtaposed to a polarized filter.

8. An apparatus according to claim 1, wherein said first and second light sensors are comprised in an array of light sensors, having at least one light sensor juxtaposed to each polarized filter.
9. An apparatus according to claim 1, wherein said filter cells are arranged in co-
5 centered rings.
10. An apparatus according to claim 1, further comprising a memory for storing complementary data of at least one of a list comprising a sun path table, an astronomical chart, a calendar chart, an ephemeris table, a time standard, a skylight polarization chart, a calibrated chart of true north, magnetic north and grid north.
- 10 11. An apparatus according to claim 1, further comprising an inclinometer for detecting the inclination of said apparatus.
12. An apparatus according to claim 2, wherein said processing unit is for calculating location data of a celestial body based on said polarization pattern.
13. An apparatus according to claim 12, wherein said location data comprises at least
15 one of azimuth and elevation of said celestial body.
14. An apparatus according to claim 12, wherein said processing unit is for calculating navigational data based on said location data of a celestial body.
15. An apparatus according to claim 14, wherein said processing unit is for calculating navigational data further based on complementary data stored in a memory.
- 20 16. A method, the method comprising:
- directing light onto an array of polarized light filter cells, each cell comprises a first polarized filter having a first polarization direction and a second polarized filter having a second polarization direction different from said first polarization direction;
- 25 producing data from light received through said first polarized filter by a first light sensor and through said second polarized filter by a second light sensor;
and
- deriving polarization pattern based on said data.

17. A method according to claim 16, wherein said second polarization direction substantially perpendicular to said first polarization direction.

18. A method according to claim 16, further comprising calculating at least one of intensity and direction of polarization by measuring the difference between the light
5 intensity received through said first polarized filter and the light intensity received through said second polarized filter and creating said polarization pattern based on said calculations.

19. A method according to claim 16, further comprising separating at least one wavelength band from said directed light.

10 20. A method according to claim 19, wherein said calculating a pattern of polarized light is in at least one separated wavelength band.

21. A method according to claim 16, further comprising detecting the inclination of said apparatus.

15 22. A method according to claim 16, further comprising calculating location data of a celestial body based on said polarization pattern.

23. A method according to claim 22, wherein said location data comprises at least one of azimuth and elevation of said celestial body.

24. A method according to claim 22, further comprising calculating navigational data based on said location data of a celestial body.

20 25. A method according to claim 24, wherein said calculating navigational data is further based on complementary data stored in a memory.