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(56) Documents Cited:
DE 004303804 A1 **JP 2005221335 A**
JP 2002236175 A **US 5589928 A1**

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INT CL **B66F, G01C, G01S, G05D**
Other: **EPODOC, WPI**

(54) Title of the Invention: **Determining the position of an automated guided vehicle**
Abstract Title: **Determining the distance of reflectors to an automated guided vehicle**

(57) A method for finding the distance of reflectors to an automated guided vehicle (AGV), wherein the reflectors are arranged in positions in a transport area (210, fig. 2). The method comprises emitting a beam B from the vehicle (200) over a search sector within the transport area (210) and receiving at the vehicle reflected signals Br from at least one of the reflecting objects. The beam B is modulated at two modulation frequencies MF1,2 so that a reflection is received from the at least one reflecting object R1 at each modulation frequency. The phase difference between the beam B and the corresponding reflected signal Br is measured to determine a distance between the at least one reflecting object R1 and a reference point on the vehicle. Range ambiguity may be solved by comparing the range of measured distances from each modulation frequency. The method may be carried out by a navigation module 100. The beam B may be modulated at each of the two modulation frequencies separately. The beam may be caused to revolve, and the modulation frequency switched after every revolution. After positional initialisation, the beam may be modulated at a single modulation frequency.

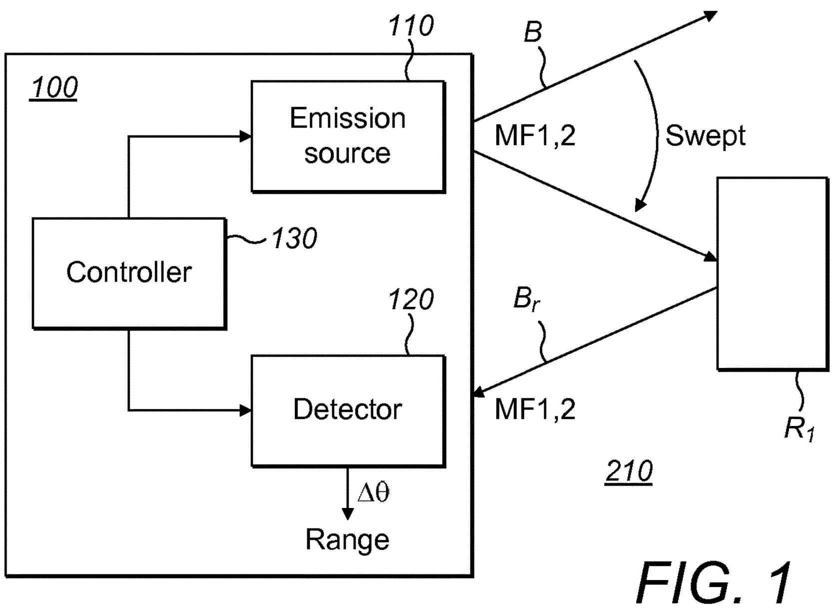

FIG. 1

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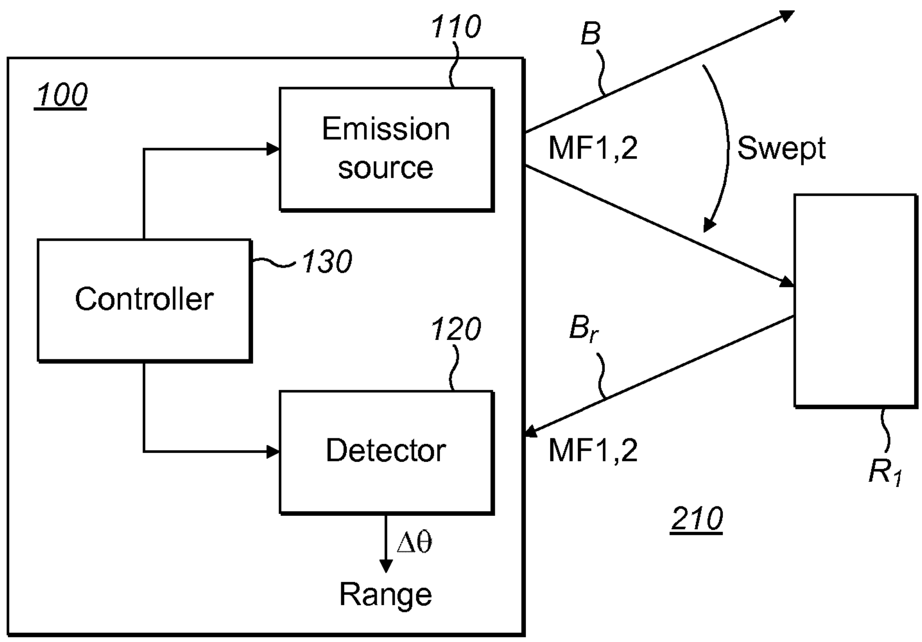
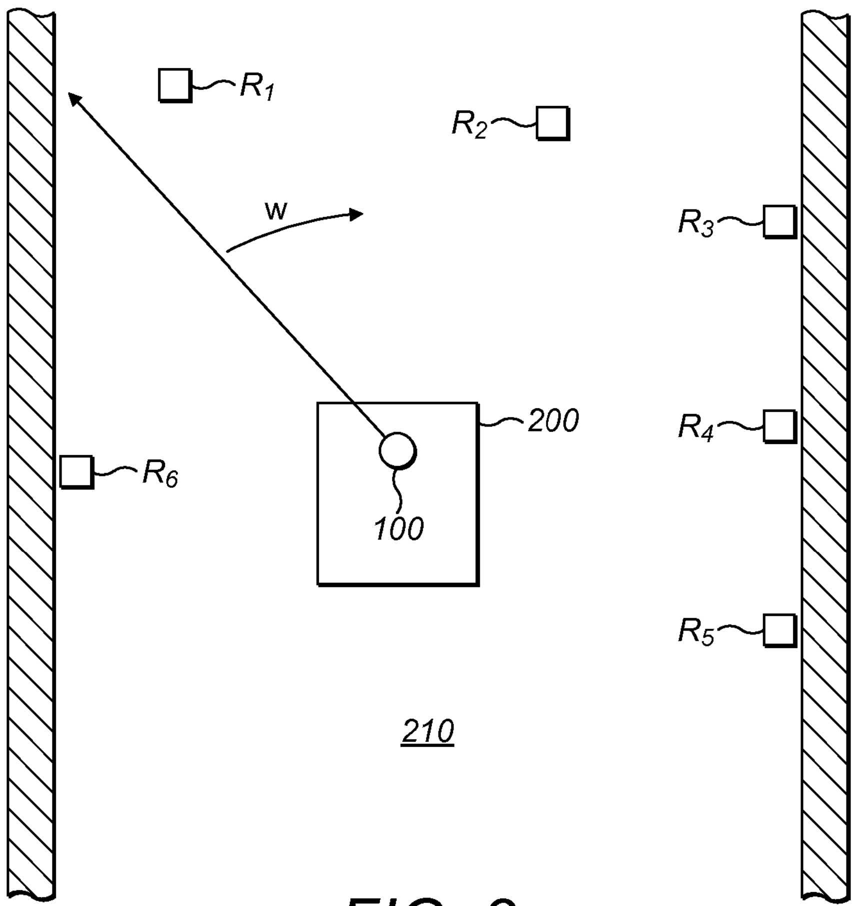


100
110
Emission source
Controller
130
120
Detector
Δθ
Range
B
MF1,2
Swept
B_r
MF1,2
R_1
210

FIG. 1



R_1
R_2
w
R_3
200
R_4
R_6
100
R_5
210

FIG. 2

Resolution of range ambiguity:

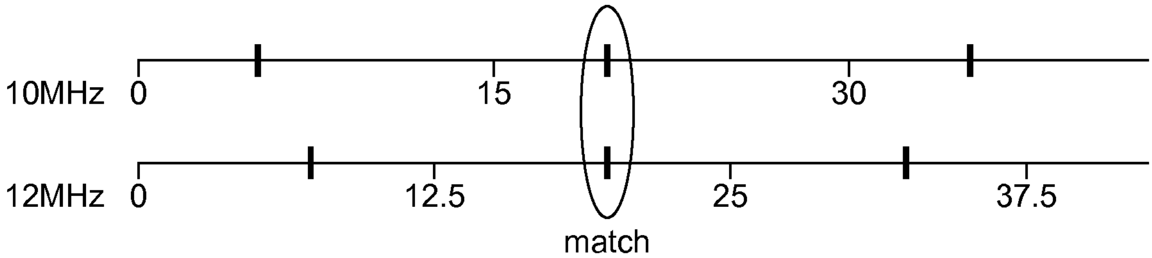


FIG. 3

Match a set of reflections to a subset of reflectors in a large map:

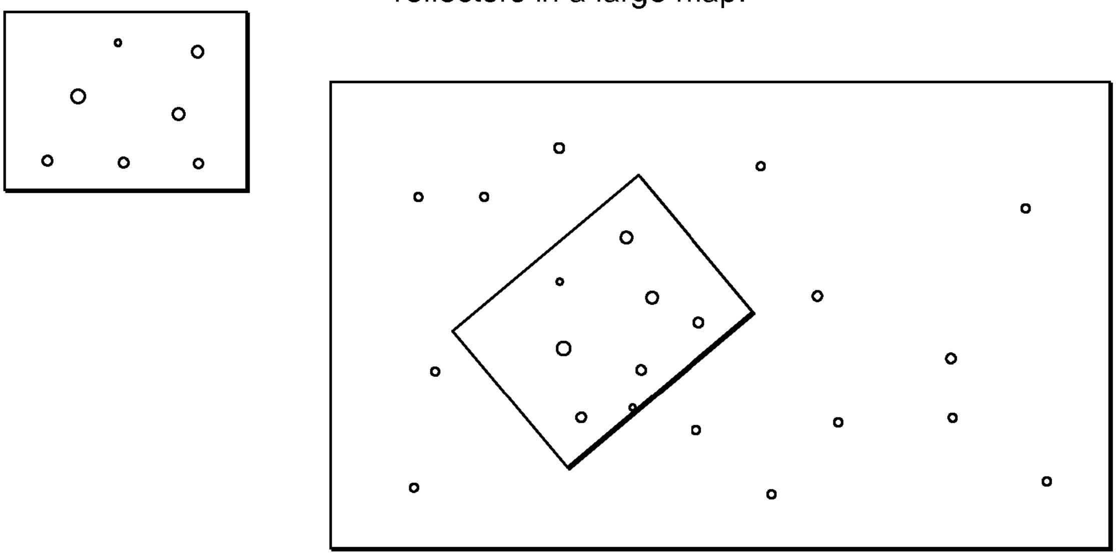


FIG. 4

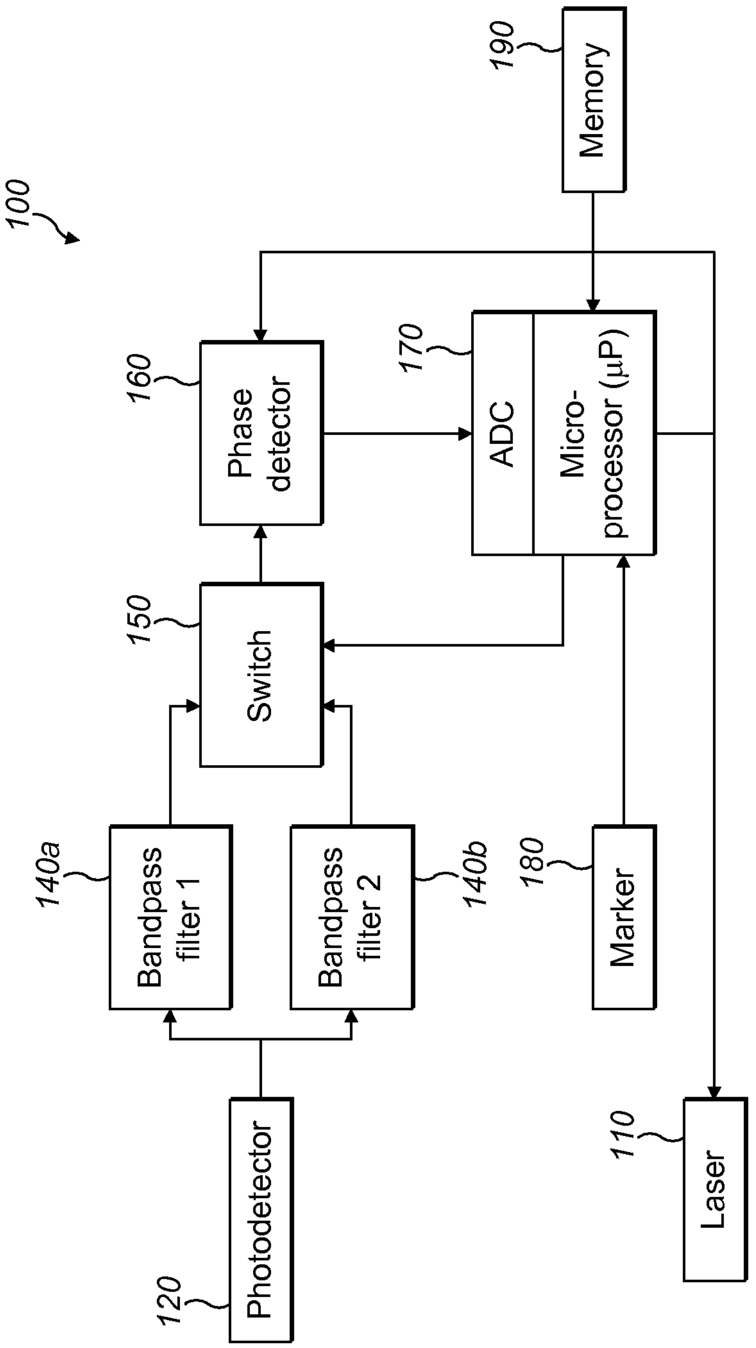

100
Photodetector
120
Bandpass filter 1
140a
Bandpass filter 2
140b
Switch
150
Phase detector
160
ADC
Micro-processor (µP)
170
Marker
180
Memory
190
Laser
110

FIG. 5

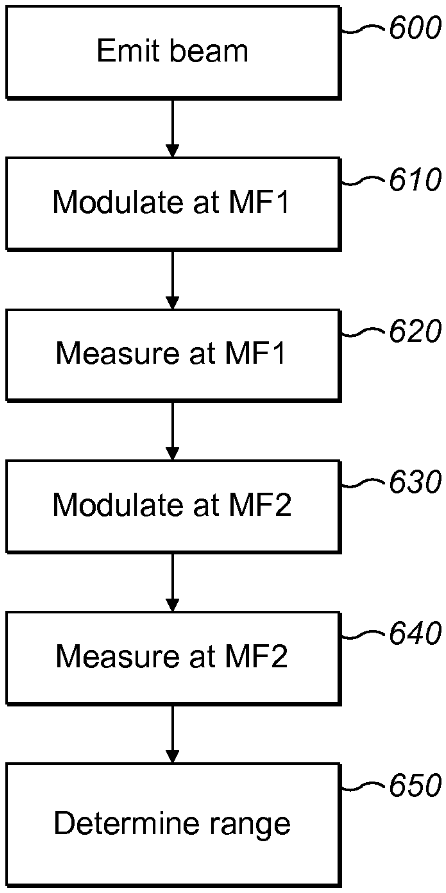

Emit beam
600
Modulate at MF1
610
Measure at MF1
620
Modulate at MF2
630
Measure at MF2
640
Determine range
650

FIG. 6

Determining the Position of an Automated Guided Vehicle

FIELD OF THE INVENTION

The invention relates to a method and apparatus for aiding the determination of a position of an automated guided vehicle (AGV). In particular, the invention assists with the association of detected anonymous reflectors with a stored reference map of reflectors to determine position of the automated guided vehicle.

BACKGROUND OF THE INVENTION

Lasers have been used for position measurement for automatic guided vehicles for nearly 30 years. An early example can be found in "Vehicle control and guidance system", US 4727492, Reeve et al, which has a priority date of 14 May 1983. The Reeve invention used a barcode to make each retro-reflector distinctive. This makes it straightforward to match a reflection to a reflector both at start up and during normal running. However, a disadvantage is this makes the retro reflectors and scanner relatively large and expensive.

A navigation system with completely anonymous reflectors, which are hence simple and inexpensive, can be found in US 4811228, Hyyppa, which has a priority date of 17 September 1985. The reflectors lack identity, but are exactly calibrated as to their position. Reflections from the reflectors are registered and are processed to calculate a position of the vehicle based on a reflector map of the calibrated reflectors.

Separately, an improvement was disclosed 10 years after Reeve et al in "Apparatus and method for identifying scanned reflective anonymous targets", US 5367458, Roberts and Miles, which has a priority date of 10 August 1993. In this invention the laser scanner measures the angle subtended by the retro-reflector. The orientation and width of each reflector is specified as part of the reflector map. Given an estimate of the scanner's position, the subtended angle can be predicted and this prediction compared to the measurement taken by the scanner. This makes it possible to associate reflections with reflectors robustly without the need for a barcode.

One relative disadvantage of both the anonymous reflector approaches put forward (Hyyppa, and Roberts and Miles) is that it is difficult to obtain an initial value for the position and heading of the scanner. Indeed, in Hyyppa the vehicle is to start in a known location, or alternatively, certain reflectors have identities, thereby negating at least some of the advantage of having an anonymous reflector solution. A solution to Roberts and Miles is feasible, but can be computationally demanding and can sometimes yield an incorrect result. This problem is more acute when there are a large number of reflectors in an installation.

For an example of a solution to this particular problem, see “Method for determining the position of an automated guided vehicle”, US 6308118, Holmquist, having a priority date of 17 October 1997. Here, an array of at least three angles relating to detected anonymous reflectors is chosen and an assumed position for the vehicle is determined on the basis of the known position of the assumed reflectors on a reflector map. Thereafter, any other reflections are matched with expected values based on the reflector map and deviations are calculated and stored. This is then repeated for each possible combination of three angle values to determine the best fit.

The 1990s saw the advent of laser scanners with range measurement capability. For example US6308118 mentioned above and “Method and device for association of anonymous reflectors to detected angle positions”, US 6259979, Holmquist, having a priority date of 17 Oct 1997 both describe how a range measurement can be used to make more certain the association of reflections to reflectors during normal operation. Here, the emitted light signal is modulated at 2 MHz and the phase of the transmitted and received signals is compared to thereby give a possible distance measurement up to 75 m.

An aim of the invention is to improve on the prior art techniques of determining the position of an automated guided vehicle. Specifically, one aim of the invention is to improve the speed and reliability of the association of detected reflectors with stored reflectors in a reflector map. Another aim is to enable larger reflector maps to be used.

SUMMARY OF THE INVENTION

According to the invention, there is provided a solution in which the accuracy of range measurement to a detected reflector is improved. This is achieved by using two frequencies of modulation to measure the distance between a reference point on a vehicle and a detected reflector. An advantage of this technique is that higher modulation frequencies (of say, more than 2 MHz) can be used to achieve better range accuracy (for 10 MHz modulation, decimetre level accuracy is achievable) without sacrificing range ambiguity (at 10 MHz, range ambiguity is around 15 m causing anonymous reflectors at 5 m, 20 m and 35 m to look the same to a scanner). Each modulation frequency could be used separately on alternative revolutions of a scanning beam. Also, once initialisation has been established, it would be possible to switch back to a single modulation frequency, having better range ambiguity.

A first aspect of the invention provides a method for finding the distance of anonymous reflectors to a vehicle. In the method, the anonymous reflectors are arranged in positions in a transport area, a beam is emitted from a vehicle over a search sector within the transport area, and reflected signals from reflecting objects are received on board the vehicle. The method provides for modulating the beam at two modulation frequencies and measuring the phase difference between the beam and a reflected signal at each modulation frequency to measure a distance between at least one reflecting object and a reference point on the vehicle.

In this way, better range accuracy is achieved while maintaining good range ambiguity. A subsequent improvement in the step of determining of the position of a vehicle would be achieved as fewer anonymous reflectors would be potential matches in an algorithm for matching detected reflector positions to a reflector map. This should be particularly useful where there is a large reflector layout, and is particularly useful in position initialisation of a stationary vehicle, where the bearing remains the same to all reflectors at both modulation frequencies.

Preferably, the beam is modulated at each of the two modulation frequencies separately. For example, the beam may be caused to revolve, and the modulation frequency may be switched after every revolution.

In one example embodiment, after positional initialisation of the vehicle is completed, the beam is modulated at a single modulation frequency. The single modulation frequency may be the same as one of the two modulation frequencies, or may be different. Preferably, the single modulation frequency is lower than the highest of the two modulation frequencies. Preferably, the single modulation frequency is lower than both of the two modulation frequencies.

While in principle, any two modulation frequencies would be feasible, it may be preferable that at least one of the two modulation frequencies is greater than 2 MHz, and more preferably greater than 5 MHz.

Preferably, the two modulation frequencies are at least 2 MHz apart. Preferably, the two modulation frequencies are between 0.5 MHz and 20 MHz. Preferably, the first of the two modulation frequencies (MF1) is from 1 MHz to 15 MHz, and is preferably around 1 MHz. Preferably, the second of the two second modulation frequencies (MF2) is from 3 MHz to 20 MHz, and is preferably around 8 MHz.

In one example embodiment, the method includes modulating the beam at three or more modulation frequencies.

A further aspect of the invention provides a navigation module for finding the distance of anonymous reflectors to a vehicle. The navigation module comprises an emission source configured to emit a beam over a search sector in a transport area when in use. The navigation module also comprises a detector configured to receive the beam when reflected by reflecting objects in the search sector. The navigation module also comprises a controller, which is configured to control the emission source to modulate the beam at two modulation frequencies. The controller is also configured to control the detector to measure any phase difference between the beam and a reflected signal at each modulation frequency so that a distance between at least one reflecting object and a reference point on the vehicle is determined.

Preferably, the beam is modulated at each of the two modulation frequencies separately. For example, the beam may be caused to revolve, and the modulation frequency may be switched after every revolution.

In one example embodiment, after positional initialisation of the vehicle is completed, the beam is modulated at a single modulation frequency. The single modulation frequency may be the same as one of the two modulation frequencies, or may be different. Preferably, the single modulation frequency is lower than the highest of the two modulation frequencies. Preferably, the single modulation frequency is lower that both of the two modulation frequencies.

While in principle, any two modulation frequencies would be feasible, it may be preferable that at least one of the two modulation frequencies is greater than 2 MHz, and more preferably greater than 5 MHz.

Preferably, the two modulation frequencies are at least 2 MHz apart. Preferably, the two modulation frequencies are between 0.5 MHz and 20 MHz. Preferably, the first of the two modulation frequencies (MF1) is from 3 MHz to 20 MHz, and is preferably around 8 MHz. Preferably, the second of the two second modulation frequencies (MF2) is from 0.5 MHz to 15 MHz, and is preferably around 1 MHz.

In one example embodiment, the method includes modulating the beam at three or more modulation frequencies.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a navigation module according to a first embodiment;

Figure 2 is a schematic plan view of an automated guided vehicle equipped with the navigation module of Figure 1, navigating a transport area;

Figure 3 is a plot showing range ambiguity at two frequencies of modulation;

Figure 4 is a schematic plan view of a reflector map together with reflector position information generated by the navigation module of Figure 1; and

Figure 5 is a more detailed schematic view of the navigation module of Figure 1; and

Figure 6 is a flow diagram explaining the operation of the navigation module of Figure 1.

DETAILED DESCRIPTION OF EMBODIMENT(S)

Figure 1 is a schematic view of a navigation module 100 according to a first embodiment of the invention.

The navigation module 100 is particularly useful for finding the distance of reflectors from a vehicle. In particular, the distance of reflectors from an automated guided vehicle (AGV). Also, in particular, anonymous reflectors. The navigation module 100 comprises an emission source 110 configured to emit a beam B over a search sector in a transport area 210. The navigation module 100 also comprises a detector 120 configured to receive the beam B when reflected by reflecting objects, such as anonymous reflector R1 in the search sector. The navigation module 100 also comprises a controller 130, which is configured to control the emission source 110 to modulate the beam B at two modulation frequencies MF1,2. The controller 130 is configured to control the detector 120 to measure any phase difference between the beam B and a reflected signal Br at each modulation frequency so that a distance between at least one reflecting object R1 and a reference point on the vehicle is determined more accurately and with lower ambiguity.

Figure 2 is a schematic plan view of the automated guided vehicle 200 equipped with the navigation module 100, navigating a transport area 210.

The transport area 210 includes many anonymous reflectors R1-R6 which are in known locations. A reflector map is made available to the navigation module 100 so that a comparison between scanned reflectors and the reflector map can be made to determine the position of the AGV 200 - see Figure 4. This process can often be computationally intense requiring a powerful microprocessor and large, fast memory. More accurate measurements of the range of each reflector reduces the uncertainty when matching scanned reflector positions to the reflector map, thereby reducing the computational requirements of the navigation module 100, enabling smaller and cheaper units. Alternatively, larger reflector maps can be handled.

In this embodiment of the invention, two modulation frequencies are used on the beam B. In particular, a 10 MHz modulation frequency MF1 is used together with a 12 MHz modulation frequency MF2.

Figure 3 is a plot showing range ambiguity at the two frequencies of modulation MF1,2. As can be seen, at 10 MHz there is a range ambiguity equal to one whole cycle of the modulation when using phase difference between emitted and reflected beams to determine the distance to a reflector. So for a 10 MHz modulated beam the reflector could be at any multiple of 15 m from the AGV (so, for example 5, 20, 35 m etc). For a 12 MHz modulated beam the reflector could be at any multiple of 12.5 m from the AGV, (so, for the same reflector, would yield results of 7.5, 20, 32.5 m etc). The range ambiguity is solved as both modulation frequencies yield a possible range of 20 m. Other modulation frequencies could be used, such as 1 MHz and 8 MHz

In particular in this embodiment, the emission source 110 is a laser and the detector 120 is a photodetector. The laser is configured to revolve so as to scan 360 degrees around the AGV 200. In this example, the modulation frequency is be switched after every revolution.

A particular strength of the invention comes in position initialisation of the AGV 200. When the AGV 200 is stationary, the navigation module 100 is able to pair measurements in the first revolution with measurements in the second revolution when all reflections are at the same bearing. The range ambiguity can then be resolved relatively easily. In this example embodiment, the combined range measurement is unambiguous up to 75 m but with the resolution expected from a 10 to 12 MHz modulation. The will give much better measurements of the separation of reflectors in view of the detector 120. This in turn will lead to the development of a more powerful association algorithm for position initialisation, and enable good position initialisation over larger transport areas 210 and reflector layouts.

After positional initialisation of the vehicle is completed, the beam in one example variation may be modulated at a single modulation frequency. The single modulation frequency may be the same as one of the two modulation frequencies, or may be different. In one example, the single modulation frequency is 2 MHz, which is lower than both of the two modulation frequencies yielding good range ambiguity at the expense of resolution.

Figure 5 is a more detailed schematic view of the navigation module of Figure 1.

Here, the controller 130 is a micro-processor arranged to control the operation of the navigation module 100. The detector 120 is connected to two band-pass filters 140a, 140b each having a centre frequency matching the first and second modulation frequencies, respectively. A switch 150 selects which output signal from the two band-pass filters 140a, 140b passes through to a phase detector 160. The micro-processor 130 sets the frequency of the modulation of the laser 110 and simultaneously sets the switch 150 to select the matching band-pass filter 140a, 140b. The phase detector 160 compares the received signal from the detector 120 with a reference signal which was used to modulate the beam output by the laser 110. The phase detector 160 then outputs a direct current signal representative of the phase difference which is measured by the micro-processor 130 via an analogue-to-digital converter (ADC) to determine the distance to the target causing the reflection of the beam.

The micro-processor 130 switches the modulation frequency of the outputted beam via laser 110 with every revolution of the laser 110. This is done using a marker 180 which provides a once per revolution pulse which is detected by the micro-processor 130 and which then triggers the micro-processor 130 to toggle the modulation frequency of the beam to another value, and switch band-pass filters accordingly. A second phase is then measured at the other modulation frequency for each reflection to resolve any range ambiguity, and this information is used in an association algorithm to determine the position of the AGV 200.

There are many ways of designing a suitable navigation module 100. The band-pass circuit could actually be one circuit having switched components to alter the centre frequency, or there may be no need for the band-pass filters or switch in an alternative arrangement.

Figure 6 is a flow diagram explaining the operation of the navigation module 100.

The method is for finding the distance of the reflectors R1-6 to an AGV 200. In the method, the reflectors are arranged in positions in the transport area 210. A beam is emitted (step 600) from the AGV 200 over a search sector within the transport area 210, and reflected signals from the reflectors, or other reflecting objects, are received on board the vehicle. The method provides for modulating the beam at a first modulation frequency MF1 (step 610) and measuring the phase difference between the beam and a reflected signal at the first modulation frequency MF1 (step 620) to determine a first set of possible distances between the at least one reflecting object and a reference point on the vehicle. The method provides for modulating the beam at a second modulation frequency MF1 (step 630) and measuring the phase difference between the beam and a reflected signal at the second modulation frequency MF2 to determine a first set of possible distances between the at least one reflecting object R1-6 and a reference point on the AGV 200. The range is determined by comparing the possible ranges from the first set of ranges using MF1 and the second set of ranges using MF2 and determining which is most likely.

In this way, better range accuracy is achieved while maintaining good range ambiguity. A subsequent improvement in the step of determining of the position of a vehicle would be achieved as fewer anonymous reflectors would be potential matches in an algorithm for matching detected reflector positions to a reflector map. This should be particularly useful where there is a large reflector layout, and is particularly useful in position initialisation of a stationary vehicle, where the bearing remains the same to all reflectors at both modulation frequencies.

While in principle, any two modulation frequencies would be feasible, it may be preferable that at least one of the two modulation frequencies is greater than 2 MHz, and more preferably greater than 5 MHz. It is advantageous that the two modulation frequencies are at least 2 MHz apart. Preferably, the two modulation frequencies are between 1 MHz and 20 MHz. Preferably, the first of the two modulation frequencies (MF1) is between 1 MHz and 15 MHz, and is preferably around 10 MHz. Preferably, the second of the two second modulation frequencies (MF2) is between 3 MHz and 20 MHz, and is preferably around 12 MHz.

In one example embodiment not discussed above, the method includes modulating the beam at three or more modulation frequencies.

Although the invention has been described above with reference to one or more preferred embodiments, it will be appreciated that various changes or modifications may be made without departing from the scope of the invention as defined in the appended claims.

It should also be said that in a typical industrial setting for an AGV, range accuracy is at or around the metre level. As mentioned in the introduction above, the preferred technique for range measurement is to modulate the outgoing laser beam at, say, 2 MHz and then to observe the phase difference between the outgoing beam and the received signal. Given that the beam dwells on the retro-reflector for some tens of microseconds, it is difficult to measure the range to better than metre level accuracy with such a phase difference technique at a modulation frequency of 2 MHz.

One solution would be to increase the modulation frequency. For example, a modulation frequency of 10 MHz would achieve decimetre level accuracy. But this brings a range ambiguity problem. At higher modulation frequencies the light reflected by a distant object does not return to the scanner until after more than one whole cycle of the modulation. As already mentioned, at 10 MHz the maximum unambiguous range is 15 m, so the signal from a reflector at 20 m cannot readily be distinguished from the signal from a reflector at 5 m.

An alternative to increasing the modulation frequency would be to use a pulsed laser and measure the time of flight of every pulse. This is known to yield range accuracies of a few centimetres. Typically a pulsed laser scanner will operate at a pulse repetition rate of tens of kHz. This brings either a reduction in the bearing resolution or a reduction in the angular speed of the laser scanner, and hence the data rate.

Claims

1. A method for finding the distance of reflectors to an automated guided vehicle, wherein the reflectors are arranged in positions in a transport area, the method comprising:

emitting a beam from the vehicle over a search sector within the transport area;

receiving reflected signals from at least one reflecting object at the vehicle;

modulating the beam at two modulation frequencies so that a reflection is received from the at least one reflecting object at each modulation frequency; and

measuring the phase difference between the beam and the corresponding reflected signal at each modulation frequency to determine a distance between the at least one reflecting object and a reference point on the vehicle.

2. The method of claim 1, wherein the beam is modulated at each of the two modulation frequencies separately.

3. The method of claim 2, wherein the beam is caused to revolve, and the modulation frequency is switched after every revolution.

4. The method of any preceding claim, wherein after positional initialisation of the vehicle is completed, the beam is modulated at a single modulation frequency.

5. The method of claim 4, wherein the single modulation frequency is lower than the highest of the two modulation frequencies.

6. The method of claim 5, wherein the single modulation frequency is lower that both of the two modulation frequencies.

7. The method of claim 4, wherein single modulation frequency is the same as one of the two modulation frequencies.

8. The method of any preceding claim, wherein at least one of the two modulation frequencies is greater than 2 MHz.

9. The method of any preceding claim, wherein the two modulation frequencies are at least 2 MHz apart.

10. The method of any preceding claim, wherein the two modulation frequencies are from 1 MHz to 20 MHz.

11. The method of any preceding claim, wherein the first of the two modulation frequencies (MF1) is from 1 MHz to 15 MHz.

12. The method of claim 11, wherein the first of the two modulation frequencies is around 1 MHz.

13. The method of any of claims 10 to 12, wherein the second of the two second modulation frequencies (MF2) is from 3 MHz to 20 MHz.

14. The method of claim 13, wherein the second of the two modulation frequencies is around 8 MHz.

15. A navigation module for finding the distance of reflectors to a vehicle, the navigation module comprising:

an emission source configured to emit a beam over a search sector in a transport area when in use;

a detector configured to receive the beam when reflected by reflecting objects in the search sector;

a controller, which is configured to:

control the emission source to modulate the beam at two modulation frequencies so that a reflected signal is received from the at least one reflecting object at each modulation frequency; and control the detector to measure a phase difference between the beam and the reflected signal at each modulation frequency so that a distance between at least one reflecting object and a reference point on the vehicle is determined.

Amendments to the claims have been filed as follows

Claims

1. A method for finding the distance of reflectors to an automated guided vehicle, wherein the reflectors are arranged in positions in a transport area, the method comprising:

emitting a beam from the vehicle over a search sector within the transport area;

receiving reflected signals from at least one reflecting object at the vehicle;

modulating the beam at two modulation frequencies so that a reflection is received from the at least one reflecting object at each modulation frequency; and

measuring the phase difference between the beam and the corresponding reflected signal at each modulation frequency to determine a distance between the at least one reflecting object and a reference point on the vehicle;

wherein the beam is modulated at each of the two modulation frequencies separately;

wherein the beam is caused to revolve, and the modulation frequency is switched after at least one revolution; and

wherein after positional initialisation of the vehicle is completed, the beam is modulated at a single modulation frequency.

2. The method of claim 1, wherein the single modulation frequency is lower than the highest of the two modulation frequencies.

3. The method of claim 2, wherein the single modulation frequency is lower that both of the two modulation frequencies.

4. The method of claim 1, wherein single modulation frequency is the same as one of the two modulation frequencies.

18 09 13

5. The method of any preceding claim, wherein at least one of the two modulation frequencies is greater than 2 MHz.

6. The method of any preceding claim, wherein the two modulation frequencies are at least 2 MHz apart.

7. The method of any preceding claim, wherein the two modulation frequencies are from 0.5 MHz to 20 MHz.

8. The method of any preceding claim, wherein the first of the two modulation frequencies (MF1) is from 1 MHz to 15 MHz.

9. The method of claim 8, wherein the first of the two modulation frequencies is 1 MHz.

10. The method of any of claims 7 to 9, wherein the second of the two second modulation frequencies (MF2) is from 3 MHz to 20 MHz.

11. The method of claim 10, wherein the second of the two modulation frequencies is 8 MHz.

12. A navigation module for finding the distance of reflectors to a vehicle, the navigation module comprising:

an emission source configured to emit a beam over a search sector in a transport area when in use;

a detector configured to receive the beam when reflected by reflecting objects in the search sector;

a controller, which is configured to:

control the emission source to modulate the beam at two modulation frequencies so that a reflected signal is received from at least one reflecting object at each modulation frequency; and control the detector to measure a phase difference between the beam and the reflected signal at each modulation frequency so that a distance between the at least one reflecting object and a reference point on the vehicle is determined;

wherein the beam is modulated at each of the two modulation frequencies separately;

wherein the beam is caused to revolve, and the modulation frequency is switched after at least one revolution; and

wherein after positional initialisation of the vehicle is completed, the beam is modulated at a single modulation frequency.

Application No: GB1216641.9 **Examiner:** Mr Tristan Ballard

Claims searched: 1-15 **Date of search:** 10 December 2012

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 2, 8-15	JP 2005221335 A (HOKUYO AUTOMATIC CO) See EPO abstract
X	1, 8-15	JP 2002236175 A (UNIV TOKYO) See EPO abstract
X	1, 8-15	US 5589928 A1 (BABBITT ET AL.) See whole document
X	1, 8-15	DE 4303804 A1 (LEUZE ELECTRONIC) See EPO abstract and WPI abstract accession no. 1994-255912/32

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B66F; G01C; G01S; G05D

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
G01S	0017/02	01/01/2006
B66F	0009/06	01/01/2006
G01S	0017/08	01/01/2006
G01S	0017/32	01/01/2006
G01S	0017/36	01/01/2006
G05D	0001/02	01/01/2006