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(56) Documents Cited
GB 2037525 A EP 0134700 A1 US 5351055 A

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INT CL^6 G01S
Online: WPI, INSPEC

(54) Displaying object with variable orientation

(57) The position of an object is represented on a screen by an icon. The position of a reference point on the object is determined in world coordinates which are transformed into screen coordinates. These are used to draw the reference point and the object onto the screen. If the contents of the screen is subsequently to be redrawn with a different orientation (eg on selection of a different direction as up, or on selection of "heading up" mode), the screen coordinates of the reference point are transformed into new screen coordinates.

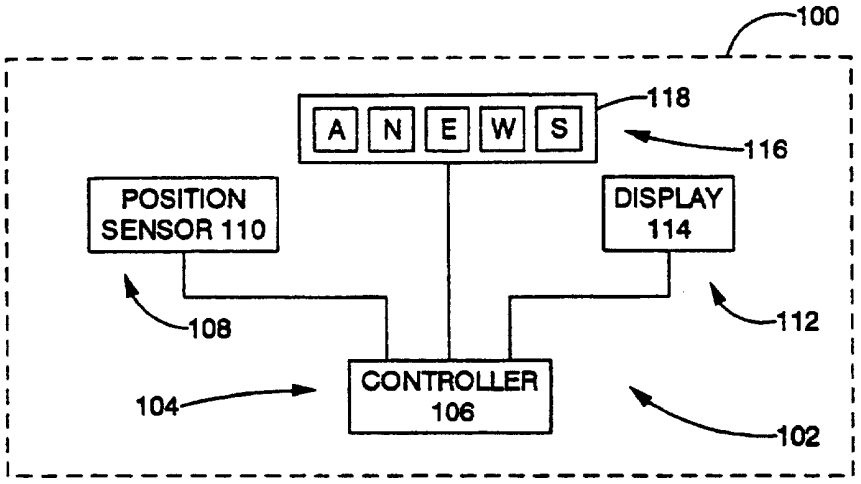

Fig 1

GB 2 312 580 A

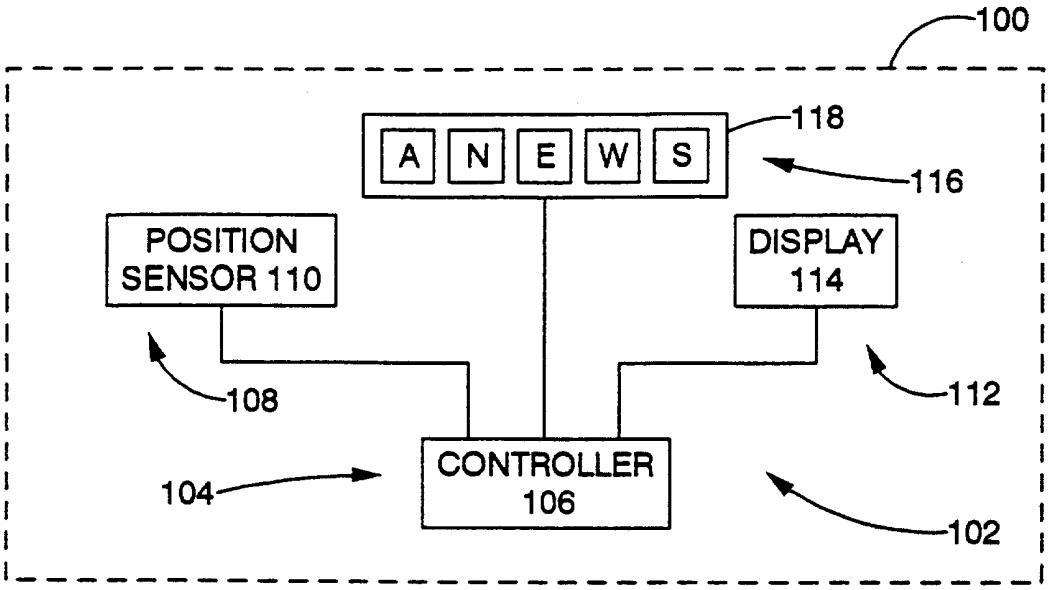
100
A
N
E
W
S
118
116
POSITION SENSOR 110
DISPLAY 114
108
112
CONTROLLER 106
104
102

Fig_1_

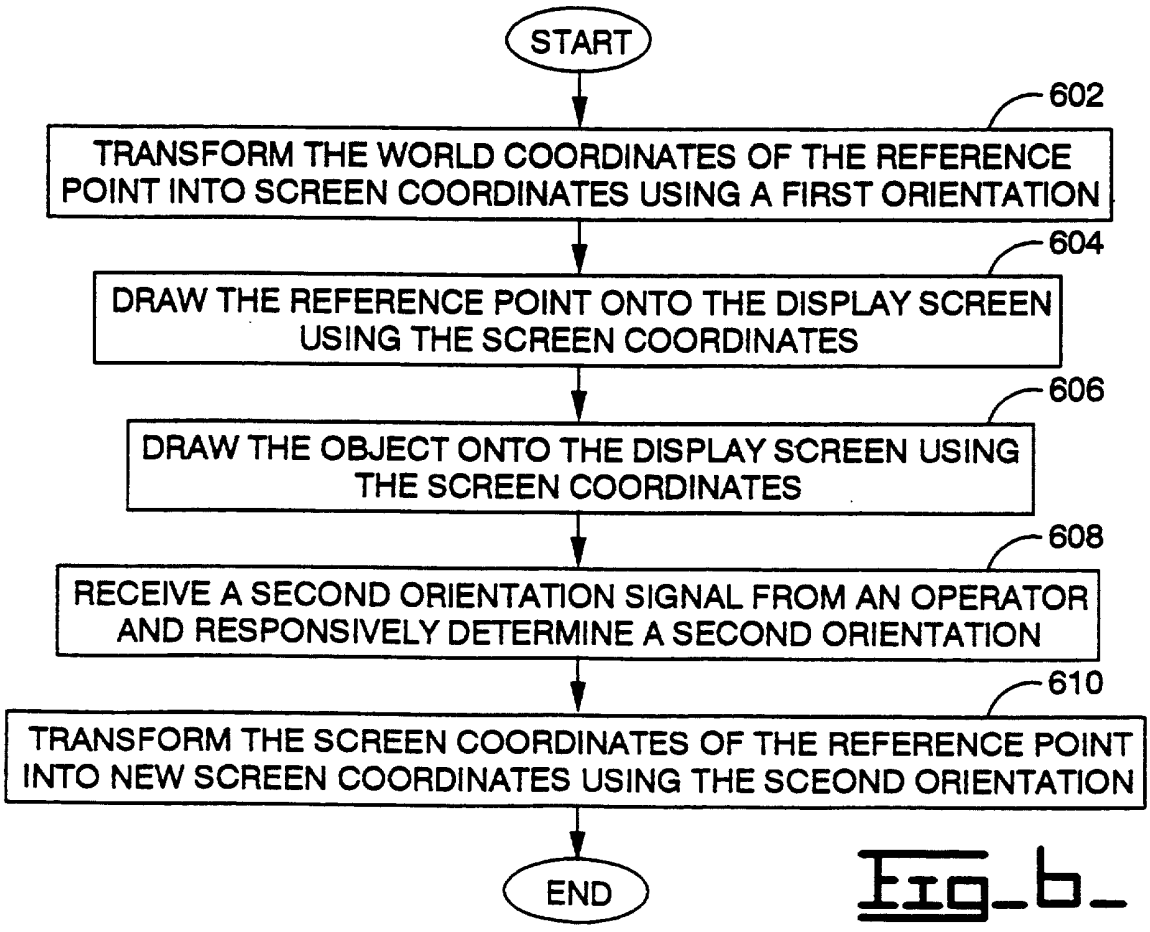
START
602
TRANSFORM THE WORLD COORDINATES OF THE REFERENCE POINT INTO SCREEN COORDINATES USING A FIRST ORIENTATION
604
DRAW THE REFERENCE POINT ONTO THE DISPLAY SCREEN USING THE SCREEN COORDINATES
606
DRAW THE OBJECT ONTO THE DISPLAY SCREEN USING THE SCREEN COORDINATES
608
RECEIVE A SECOND ORIENTATION SIGNAL FROM AN OPERATOR AND RESPONSIVELY DETERMINE A SECOND ORIENTATION
610
TRANSFORM THE SCREEN COORDINATES OF THE REFERENCE POINT INTO NEW SCREEN COORDINATES USING THE SCEOND ORIENTATION
END

Fig_6_

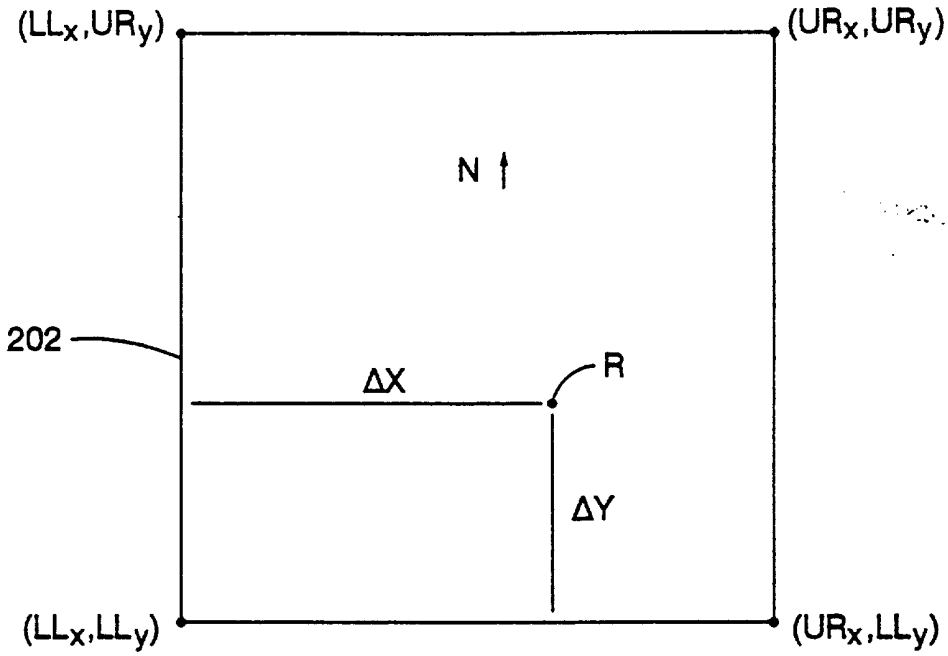
(LLx,URy)
(URx,URy)
N
202
ΔX
R
ΔY
(LLx,LLy)
(URx,LLy)

Fig_2_

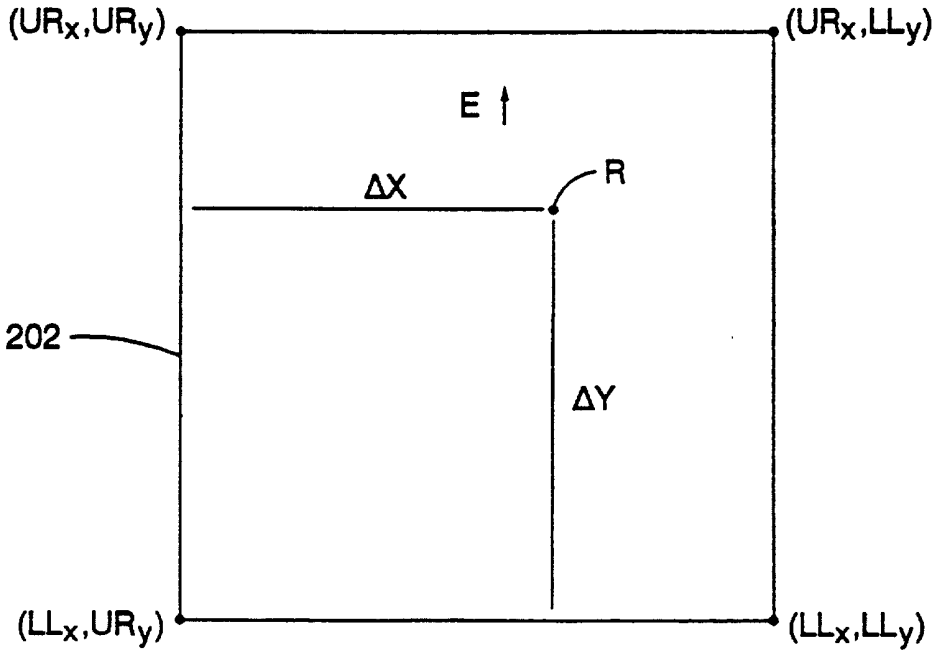
(URx,URy)
(URx,LLy)
E
ΔX
R
202
ΔY
(LLx,URy)
(LLx,LLy)

Fig_3_

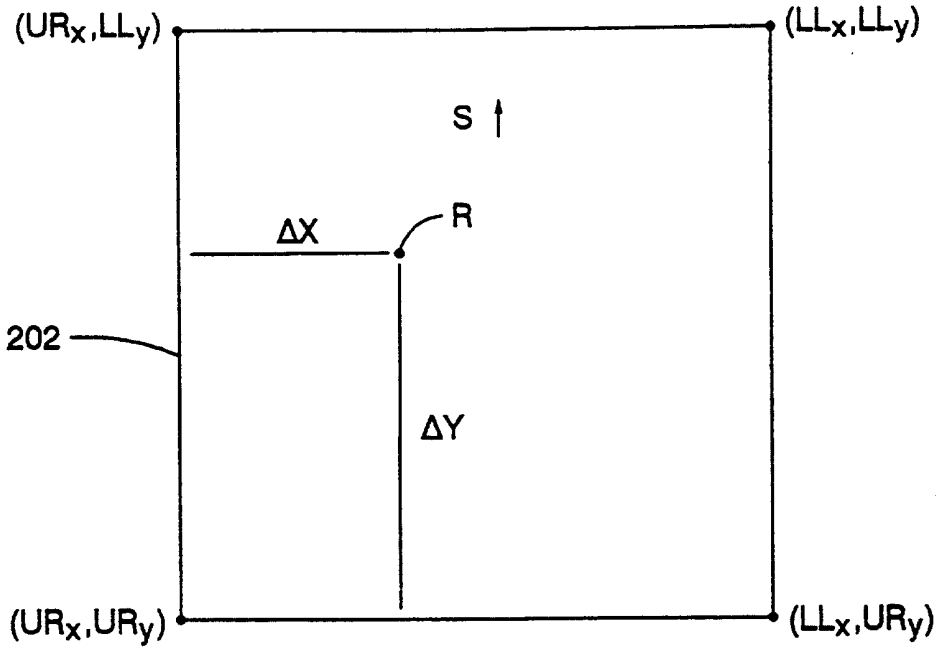
(URx,LLy)
(LLx,LLy)
S
ΔX
R
202
ΔY
(URx,URy)
(LLx,URy)

Fig_4_

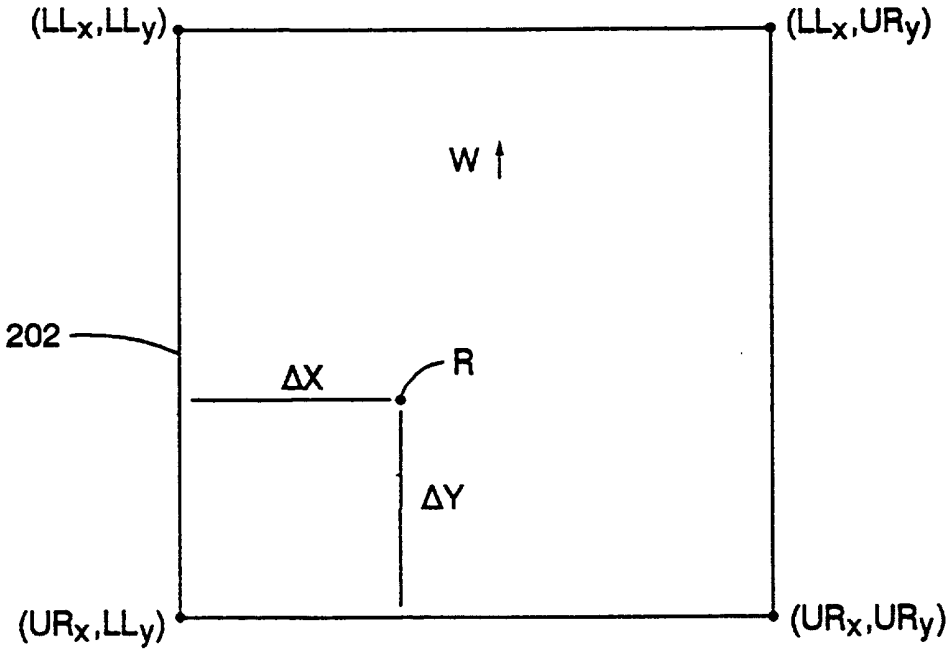
(LLx,LLy)
(LLx,URy)
W
202
ΔX
R
ΔY
(URx,LLy)
(URx,URy)

Fig_5_

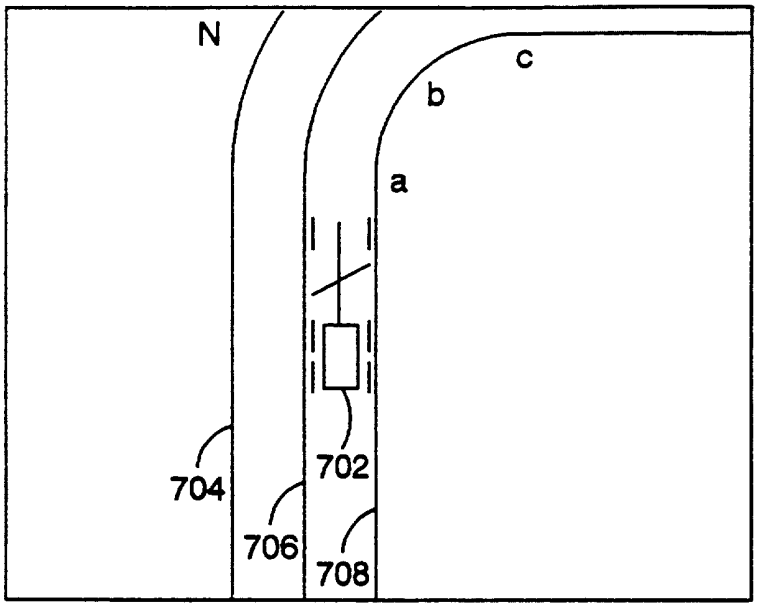

Fig_7_

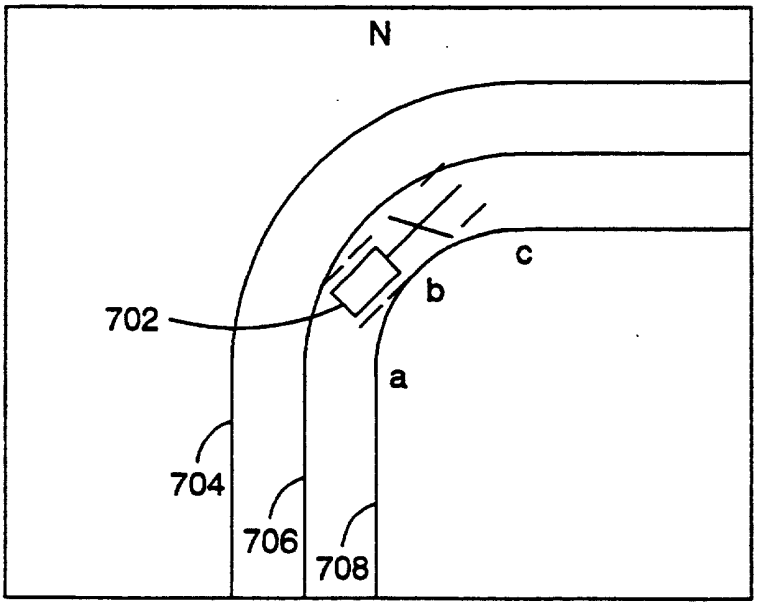

Fig_8_

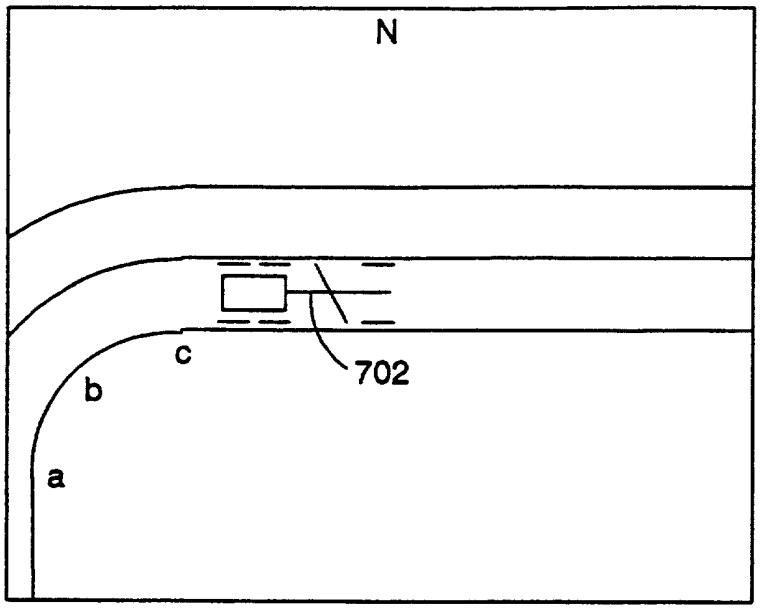

Fig_9_

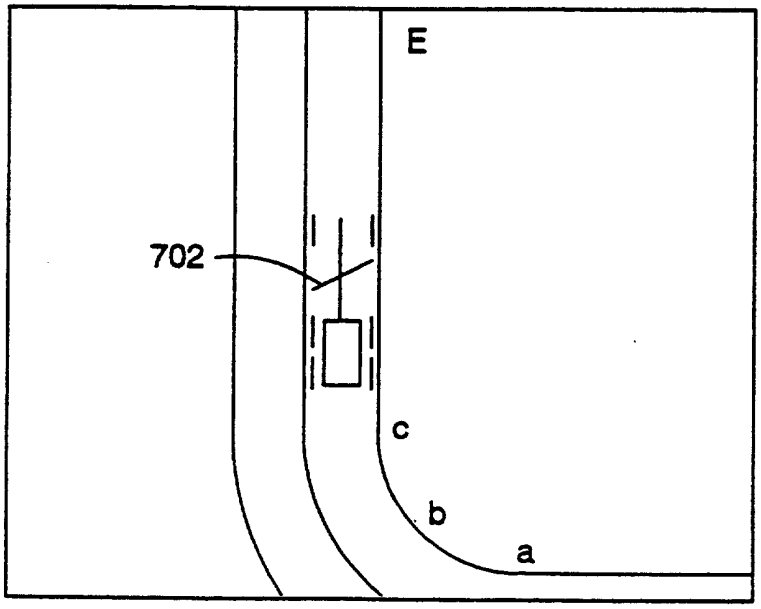

Fig_10_

Displaying a Virtual Object on a Display Screen

The invention described herein was made in the performance of work under NASA Contract No. NCC2-9007 and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958 (42 U.S.C. 2457).

The present invention relates generally to a method for displaying a virtual object on a display screen, and more particularly, to a method for automatically changing the orientation of the screen image.

Computer based systems for displaying the actual position of a mobile machine are becoming more common. Such systems utilize a positioning system, for example, a Global Positioning System (GPS). GPS uses a set of GPS satellites and a GPS receiver to determine the position of the machine. The machine can then be displayed on a display screen to the operator. Relevant site information is also typically displayed on the display screen.

For example, in the automotive field an icon representing an automobile may be displayed on a map with street information. In such systems, the orientation of the display remains constant, i.e., north is up. The icon is usually rotated to indicate the heading.

However, in some applications it may be preferable to have the front of the machine icon point

toward the top of the display screen. for better viewing by the machine's operator.

For example, in the aviation field, an icon representing an airplane may be displayed along with topographical information. In such systems, the icon usually remains centered in the display and the map of topographical information is rotated and moved beneath the icon. However, such systems require a tremendous amount of computing power to continuously update the map data on the screen.

The present invention is aimed at solving one or more of the problems indicated above.

In one aspect of the present invention, a method for displaying a virtual object on a display screen is provided. The virtual object has a virtual reference point in world coordinates. The display screen has a first orientation. The method includes the steps of transforming the world coordinates of the reference point into screen coordinates using the first orientation, drawing the reference point onto the display screen using the screen coordinates, and drawing the object onto the display screen using the screen coordinates. The method further includes the steps of receiving a signal from an operator indicative of a second orientation and transforming the screen coordinates of the reference point into new screen coordinates using the second orientation.

In another aspect of the present invention, a method for displaying a virtual object on a display screen is provided. The virtual object has a virtual

reference point and is representative of an actual object having an actual reference point. The display screen has a first orientation. The method includes the steps of sensing a set of world coordinates of the actual reference point, transforming the world coordinates into screen coordinates of the virtual reference point using the first orientation, and drawing the reference point and the object onto the display screen using the screen coordinates. The method further includes the steps of receiving a signal indicative of a second orientation from an operator, transforming the screen coordinates of the reference point into new screen coordinates using the second orientation, and drawing the reference point and the object onto the display screen using the new screen coordinates.

Brief Description of the Drawings

Fig. 1 is a diagrammatical illustration of an apparatus for performing the present invention;

Fig. 2 is a diagrammatical illustration of a display screen with a North orientation illustrating world coordinates;

Fig. 3 is a diagrammatical illustration of a display screen with an East orientation illustrating world coordinates;

Fig. 4 is a diagrammatical illustration of a display screen with a South orientation illustrating world coordinates;

Fig. 5 is a diagrammatical illustration of a display screen with a West orientation illustrating world coordinates;

Fig. 6 is a flow diagram, illustrating operation of the present invention according to an embodiment of the present invention;

Fig. 7 is a graphical illustration of a sample display screen;

Fig. 8 is a graphical illustration of a second sample display screen;

Fig. 9 is a graphical illustration of a third sample display screen; and,

Fig. 10 is a graphical illustration of a fourth sample display screen.

With reference to Fig. 1, the present invention provides a method for displaying a virtual object on a display means 112. The display means includes a display screen 114. The virtual object represents an actual object having an actual reference point.

For example, in the preferred embodiment the actual object is an earthmoving or mobile machine 100. The mobile machine 100 operates at a work site.

The present invention is embodied in an apparatus 102. The apparatus 102 includes a controlling means 104.

In the preferred embodiment, the controlling means 104 includes a microprocessor-based controller 106.

The controlling means 104 receives position information from a positioning means 108 and controls the display means 112.

The positioning means 108 determines the location or position of a reference point on the mobile machine 100. The positioning means 108 may also determine the heading of the machine 100. The position of the reference point is preferably expressed in world coordinates. World coordinates may be based on a terrestrial coordinate system or a site coordinate system.

In one embodiment, the positioning means 108 includes a GPS receiver (not shown). In another embodiment, the positioning means 108 includes a laser plane system. The positioning means 108 may also include any suitable positioning system or combination of positioning systems.

One suitable system for determining the position of a reference point on the machine 100 and displaying an icon of the machine 100 and other site information is disclosed in U.S. Patent 5,471,391 issued to Adam J. Gudat and Daniel E. Henderson on 28 November 1995 which is herein incorporated by reference.

The present invention provides a method by which the orientation, e.g., North is up, of the display screen is modified based on operator input.

An operator input means 116 allows the operator to input a desired mode or desired orientation. In the preferred embodiment, the operator input means 116 includes a selector 118. The selector may include five input buttons, labeled "A", "N", "E", "W", and "S". As discussed below, operator actuation of "A" places the system in an automatic mode where

the orientation of the display screen is based on the heading of the mobile machine 100. Actuation of one of the other buttons causes the system to orientate the display 114 to a specific orientation:

"N": North is up;

"E": East is up;

"W": West is up; and

"S": South is up.

With reference to Fig. 6, a first embodiment of the present invention will now be discussed.

The world coordinates of the reference point of the actual object are determined by the positioning means 108.

In the preferred embodiment the map, i.e., the icon representing the actual object and the map data are displayed on a portion of the display 114. Preferably, the map is displayed in a square.

With reference to Figs. 2-5, the corners of the square 202 in which the map is displayed are expressed in world coordinates.

With specific reference to Fig. 2, the map has the orientation of North being up. In world coordinates, the corners are expressed as:

Upper Left Corner: (LL_X, UR_Y);

Upper Right Corner: (UR_X, UR_Y);

Lower Left Corner: (LL_X, LL_Y); and

Lower Right Corner: (UR_X, LL_Y).

Returning to Fig. 6, in a first control block 602 the world coordinates of the reference point are transformed into screen coordinates using the first orientation.

Returning to Fig. 8, assuming the first orientation is North is up, the screen coordinates are expressed as a difference in the X direction (ΔX) and a difference in the Y direction (ΔY) from the bottom left corner. Preferably, ΔX and ΔY are expressed in pixels.

Thus, ΔX and ΔY can be determined by:

$$\Delta X = |LL_X - R_X| * \text{CONVERSION\_FACTOR}$$

$$\Delta Y = |LL_Y - R_Y| * \text{CONVERSION\_FACTOR},$$

where, CONVERSION_FACTOR is a conversion factor for converting millimeters to pixels. The CONVERSION_FACTOR is a constant or based on an operator selected ZOOM level.

Returning again to Fig. 6, in a second control block 604 the reference point R is drawn onto the display screen using the screen coordinates. R_X, R_Y are the world coordinates of the reference point.

In a third control block 606, the virtual object is drawn onto the display screen using the screen coordinates. In one embodiment, the virtual object is drawn based on the reference point and the heading. In another embodiment, a second reference point is transformed into screen coordinates in a similar manner. The virtual object can then be drawn on the screen using the screen coordinates of the two reference points.

In a fourth control block 608, a signal is received from the operator via the operator input means 116. A second orientation (as described below) is determined as a function of the signal.

In a fifth control block 610, the screen coordinates of the reference point are transformed into new screen coordinates using the second orientation.

If the operator selects one of the other orientations, i.e., East is up ("E"), West is up ("W"), or South is up ("S"), then the orientation of the display screen is modified accordingly and the map and icon redrawn.

With reference to Fig. 3, if East is the new or second orientation, then the screen coordinates of the reference point are expressed as a ΔX and ΔY from the bottom left corner. As shown, the bottom left corner is now expressed as LL_X, UR_Y in world coordinates. This, ΔX and ΔY are determined by:

$$\Delta X = |UR_Y - R_Y| * \text{CONVERSION\_FACTOR, and}$$

$$\Delta Y = |R_X - LL_X| * \text{CONVERSION\_FACTOR.}$$

With reference to Fig. 4, if South is the new or second orientation, then the screen coordinates of the reference point are expressed as a ΔX and ΔY from the bottom left corner. As shown, the bottom left corner is now expressed as UR_X, UR_Y in world coordinates. Thus, ΔX and ΔY are determined by:

$$\Delta X = |UR_X - R_X| * \text{CONVERSION\_FACTOR, and}$$

$$\Delta Y = |UR_Y - R_Y| * \text{CONVERSION\_FACTOR.}$$

With reference to Fig. 5, if West is the new or second orientation, then the screen coordinates of the reference point are expressed as a ΔX and ΔY from the bottom left corner. As shown, the bottom left corner is now expressed as UR_X, LL_Y in world coordinates. Thus, ΔX and ΔY are determined by:

$$\Delta X = |R_Y - LL_y| * CONVERSION\_FACTOR, \text{ and}$$
$$\Delta Y = |UR_x - R_X| * CONVERSION\_FACTOR.$$

The new or second orientation may also be determined automatically, i.e., the signal from the operator indicates that "A" has been selected. Preferably, the second orientation is selected such that the display screen is oriented with one direction, e.g., East, facing directly up and the machine 100 is facing substantially in that direction.

The new heading is a function of the first orientation and the heading of the machine 100. The heading is compared with the first or current orientation and updated if the heading varies from the orientation by a predetermined threshold.

For example, if the first orientation is North and the heading indicates that the machine 100 is facing a direction which varies from North by a predetermined threshold, e.g., 50°, then the orientation is updated and the second orientation is set to either East or West, depending upon the heading.

With reference to the drawings and in operation, the present invention provides a method for displaying a virtual object on a display screen. The virtual object represents an actual object, such as an earthmoving machine 100 operating at a work site. The method also displays other objects or aspects of the work site, such as obstacles or compaction.

The present invention assists the operator in performing work functions at the site by allowing the operator to orientate the display screen in a desired direction or by allowing automatic orientation.

With reference to Figs. 7-10, operation of the present invention will now be illustrated.

As shown, the icon 702 represents a motorgrader. The map is orientated with North being up and illustrates road lines 704, 706, 708.

In this embodiment, the icon 702 stays in the center of the display. However, the present invention is also applicability to other systems in which the icon 702 does not remain centered.

As shown in Fig. 8 and 9, the icon 702 is rotated and the map data is rotated/moved under the icon 702 to show movement of the motorgrader.

However, as shown in Fig. 10, when the operator selects the "E" button on the selector, the display is re-orientated.

While the present invention has been discussed with regard to a machine 100, the present invention may also be utilized to display other site data, e.g., obstacles, road lines, ore bodies, etc....

Other aspects, features, and advantages of the present invention may be determined by a study of the specification, drawings, and appended claims.

CLAIMS

1. A method for displaying a virtual object on a display screen, the virtual object having a virtual reference point in world coordinates, the display screen having a first orientation, comprising:

transforming the world coordinates of the reference point into screen coordinates using the first orientation;

drawing the reference point onto the display screen using said screen coordinates;

drawing the object onto the display screen using said screen coordinates;

receiving a signal from an operator and responsively determining a second orientation; and,

transforming said screen coordinates of the reference point into new screen coordinates using the second orientation.

2. A method, as set forth in claim 1, including the steps of:

drawing the reference point onto the display screen using said new screen coordinates; and

drawing the object onto the display screen using said new screen coordinates.

3. A method, as set forth in claim 1, wherein the virtual object represents an actual object having an actual reference point.

4. A method, as set forth in claim 2, including the step of sensing the world coordinates of the actual reference point.

5. A method, as set forth in claim 1, wherein said signal from the operator is indicative of said second orientation.

6. A method, as set forth in claim 3, wherein said signal from the operator is indicative of an automatic orientation mode.

7. A method, as set forth in claim 6, including the steps of:

determining a heading of said actual object; and,

comparing said heading with the first orientation.

8. A method, as set forth in claim 7, wherein said second orientation is determined only if the heading varies from the first orientation by more than a predetermined threshold.

9. A method for displaying a virtual object on a display screen, the virtual object having a virtual reference point and being representative of an actual object having an actual reference point, the display screen having a first orientation, comprising:

sensing a set of world coordinates of the actual reference point.

transforming said world coordinates into screen coordinates of the virtual reference point using the first orientation;

drawing the reference point onto the display screen using said screen coordinates;

drawing the object onto the display screen using said screen coordinates;

receiving a signal from an operator, the signal being indicative of a second orientation;

transforming said screen coordinates of the reference point into new screen coordinates using the second orientation;

drawing the reference point onto the display screen using said new screen coordinates; and

drawing the object onto the display screen using said new screen coordinates.

10. An apparatus for displaying a virtual object, the virtual object having a virtual reference point in world coordinates, the apparatus comprising:

a display screen, the display screen having a first orientation;

means for transforming the world coordinates of the reference point into screen coordinates using the first orientation;

means for drawing the reference point onto the display screen using said screen coordinates;

means for drawing the object onto the display screen using said screen coordinates;

means for receiving a signal from an operator and responsively determining a second orientation; and,

means for transforming said screen cordinatates of the reference point into new screen coordinates of the reference point into new screen coordinates using the second orientation.

11. An apparatus for displaying a virtual object, the virtual object having a virtual reference point and being representative of an actual object having an actual reference point, the apparatus comprising:

a display screen, the display screen having a first orientation;

means for sensing a set of world coordinates of the actual reference point;

means for transforming said world coordinates into screen coordinates of the virtual reference point using the first orientation;

means for drawing the reference point onto the display screen using said screen coordinates;

means for drawing the object onto the display screen using said screen coordinates;

means for receiving a signal from an operator, the signal being indicative of a second orientation;

means for transforming said screen coordinates of the reference point into new screen coordinates using the second orientation;

means for drawing the reference point onto the display screen using said new screen coordinates; and

means for drawing the object onto the display screen using said new screen coordinates.

12. A method substantially as described with reference to the accompanying drawings.

13. An apparatus substantially as described with reference to the accompanying drawings.

The Patent Office

15

Application No: GB 9702806.2
Claims searched: all

Examiner: Dr E P Plummer
Date of search: 23 April 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4D (DAB, DSDX, DSDB, DSDC, DSDD, DLSX); G1G (GEJ)

Int Cl (Ed.6): G01S

Other: Online: EDOC, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2037525A	Furuno	
A	EP0134700A1	Sperry	
A	US5351055	Furuno	

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.