

A Knowledge-Based Mapping and Planning Apparatus for Mobile Vehicle

Field of the invention

- 5 The present invention relates to a knowledge-based mapping and planning apparatus to localize and navigate a mobile robot or a mobile vehicle in an indoor environment, such as hospital or office environment.

Background of the Invention

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Enhancing productivity has been becoming a most challenging task for most advanced economic entities, such as USA, Europe and Singapore. It is not only focus on the automation in industry and manufacture section, but also on servicing section such as hospital, office, restaurant, super market, shopping center and so on.

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Limited by the re-construction of a building for an automatic system in the servicing environment, the servicing robot has been emerging in the servicing environment to increase productivity in some countries. Although the adoption rate has been speeding up since the starting of 21st century, the wide adoption is dependent greatly on the technologies referring to navigation, mobile mapping and task planning system to meet the requirement of safety, reliability, and easy operation for specified task at reasonable cost. Obviously, the environment independent mobile mapping system is most critical on it, which will build the localization and navigation system for a servicing robot or vehicle to perform a serial tasks in the servicing environment without the need of re-construction it.

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There are many technologies to build a mapping based localization and navigation system for mobile vehicle, such as satellite based Global Position System (GPS), Inertial Measurement Unit (IMU) based navigation technology,

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imagery recognition based mapping technology, Radio Frequency Identification (RFID) based position and location system, laser based range identification technology and so on. Basically, these technologies are not requiring to changing the construction (may need some beacons at some waypoints).

5 However, the mapping accuracy for localization and navigation for a mobile vehicle or robot moving in indoor environment is not enough or not safety in a public environment. Therefore, the most technologies and products adopted are still the traditional tracking technologies, including magnetic tape or points tracking, optical tape tracking, vacuum channel and rail tracking, which need to
10 add a fixed tracking system in the building and is not easy to change it.

To enhance the productivity for servicing section in an economic entity through automating the servicing procedures, the critical issue is to develop a precise real-time mapping system for localization and navigation of mobile vehicle or
15 robot, which needs not any re-construction on the servicing environment.

Summary of the invention

20 The present invention aims to provide an environment independent real-time mapping and planning apparatus for localization and navigation of mobile vehicle or robot in servicing section or indoor environment. It is micro-processor embedded digital apparatus with knowledge-based trajectory recognition and planning system.

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In general, the present invention is an intelligent apparatus for localization and navigation a mobile vehicle, which comprises three functional components; a navigation component with several digital navigation units to collection navigation information from varies trajectories during the movement of a mobile
30 vehicle or robot; a position component with several position units to identify special targets for special tasks; and a micro-processor based digital mapping

and planning component comprises with an advanced signal processing unit, which provides the output in numerical format to RS232 or USB ports. Three functional components together with a knowledge-based specialist system builds an intelligent mapping and planning apparatus, enabling the mapping and
5 planning the navigation of a mobile vehicle or robot without necessary of re-construction of the current building.

The knowledge-based mapping and planning system allows the mobile vehicle or robot moving along the planned trajectory to a specified target to perform a
10 specified task. The trajectory will be decided by the knowledge-based mapping and planning system through two ways; the first way is moving the mobile vehicle or robot with the apparatus invented along the expected trajectory so that the robot will remember the trajectory; the second way is working out a virtual trajectory for the robot to navigation. Of cause, the virtual trajectory
15 should be a possible trajectory in a building to allow the robot moving. It needs the mapping of the building, but no need to re-construct the build.

The accuracy and precision of the robot navigation along the trajectories are decided by the digital navigation units. A set of needle wheels have been
20 invented for the navigation unit to prevent slipping during the movement of the robot or vehicle. In this way, the navigation of a robot or vehicle will be depend on the mapping and planning apparatus invented, but not the driving system of the robot or vehicle. A set of encoders with resolution up to 0.1mm are used to feed back the position information during the movement of the robot or vehicle.
25 Therefore, the navigation accuracy and precision of the robot or vehicle will reach the scale of 1mm, which is enough for a robot or mobile vehicle working in most servicing environment.

The apparatus could be installed on any mobile vehicle or robot, providing
30 parameter or information to control the vehicle or robot moving on a planning trajectory or new specified trajectory.

Brief Description of the Figures

An embodiment of the invention will now be illustrated for the sake of example only with reference to the following drawings, in which:

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Fig. 1 is an overall perspective view of the apparatus 100 according to an embodiment of the present invention. It is a one block apparatus supported by a basic plate 101.

10 Fig. 2 is a front view of the overall perspective view of the apparatus. It shows the positions of two positioning units 201 and 202. It also shows the layouts and positions of three digital navigation units 203, 204 and 205, which have been placed on the same distance L between two digital navigation units. Two mounting holes 206 enable a simple integration for the apparatus and vehicle. 207 is the cover of micro-processor based digital mapping and planning
15 module 403.

Fig. 3 is a bottom view of the overall perspective view of the apparatus. It shows that the two positioning units and three digital navigation units are placed on the same line.

20 Fig. 4 is an overall perspective view of apparatus with a section view Z-Z. Three springs 401, 402 and 404 provide the forces for three digital navigation units 203, 204 and 205 along the same direction. The micro-processor based digital mapping and planning unit 403 has been built inside the basic plate 101.

25 Fig. 5 is perspective view of digital navigation unit. It composes by two needle wheels 501, encoder 502, support frame 503, wire and guide pipe 504, and ball spline 505.

Fig. 6 is the front view of digital navigation unit. The centres line of ball spline and guide pipe are all crossing the centre of two needle wheels.

30 Fig. 7 is the perspective view the digital navigation unit with Z-Z section view to show the position of encoder 701 inside the unit. Two ball bearings 702 on two sides of two needle wheels tenable these wheels moving smoothly.

Fig. 8 is a perspective view of needle wheel 203, 204 and 205. The support disk 801 on two needle wheels are on the same center line. The needles 801 are fixed on the disk at the same distance. For the embodiment, 12 needles on one needle wheel are placed on 30° each. The needle angle of 15° is between the needles on two needle wheels.

Fig. 9 is a perspective view of layout of two needle wheels. A distance of L1 is on the two wheels.

Fig. 10 is the functional block diagram of the micro-processor based digital mapping and planning unit 403. DC power 1002 provides all of power for the unit 403, three encoders 1003 and two position units 1004. Micro-processor 1001 will handle all of signals and data from encoders and position units.

Fig. 11 is the bottom perspective view of the apparatus invented on a four wheels vehicle. The digital navigation unit 204 is at the center 1100 of four driving wheels of the vehicle.

Fig. 12 is the front perspective view of the apparatus invented on a four wheels vehicle. Three digital navigation units 203, 204, and 205 have been pressed on the ground by three springs 401, 402 and 404.

Fig. 13 shows the tracking of three digital navigation units on a straight trajectory. The distance between the trajectory 1301 by unit 203 and the trajectory 1302 by unit 204 are keeping constant and the same with the distance between the trajectory 1303 by unit 205 and the trajectory 1302 by unit 204.

Fig. 14 shows the tracking of three digital navigation units on a curved trajectory. The angle for trajectory 1401 of digital navigation unit 203 is R1. The angle for trajectory 1402 of digital navigation unit 204 is R2. The angle for trajectory 1403 of digital navigation unit 205 is R3.

Detailed Description of the Embodiments

5 A knowledge-based mapping apparatus which is an embodiment of the invention will now be described with reference Fig. 1 to Fig. 14. The apparatus comprises three functional components:

- Navigation component comprises with three digital navigation units 203, 204 and 205. Three digital navigation units have been fixed on a support plate with equal distances.
- 10 • Position component comprises with two position units 201 and 202. The position unit is built by infra sensor and related circuits. Two position units have been fixed on the support plate in line with three digital navigation units 203, 204, and 205.
- Micro-processor based digital mapping and planning component
15 comprises with an advanced signal processing unit, which provides the output in numerical format to RS232 or USB ports.

The apparatus will be mounted on a mobile vehicle or robot by two screws through two mounting holes 206.

20 The functions of navigation component are mainly providing a set of digital signals during the movement of the apparatus carried by a mobile robot or vehicle. It comprises three digital navigation units 203, 204 and 205, fixed on the support plate 101 with distances L between them. There are two needle wheels 801 and 802 on each digital navigation units. The three digital
25 navigation units will be pressed by three springs 401, 402 and 403 to the ground with a constant pressure.

The needles wheels are supported by two ball bearings 702 and will be turning during the movement of the mobile robot or vehicle, in which the apparatus has
30 been installed. A digital encoder, either magnetic or optical encoder, is fixed on the shaft of two needle wheels on a digital navigation unit as shown in Fig 5 and

Fig 6, so the movement signals of the mobile vehicle are digitalized and sent to the micro-processor based digital mapping and planning component 403.

5 The needle wheels and encoder is supported by the support frame 503. A ball spline fixed on the frame to limit the digital navigation unit to be moved only one direction by a spring 401 or 402 or 403. The guide pipe 504 prevents the unit turning along the axis of ball spline and enables the cable from encoder passing through the digital navigation unit to the component 403.

10 The needle wheel 801 or 802 comprises of a set of needles at the same angle. Two needle wheels on the digital navigation unit are fixed on a shaft with a distance L1 as shown in Fig 9. Any needle on 801 will be placed on the centre any two needles on 802.

15 The position units 201 and 202 are built by normal positioning sensors. Two position units 201 and 202 are installed on the support plate 101 in line with three digital navigation units 203, 204 and 205, as shown in Fig3. The two position unit will receive the position signals from special positions to perform special tasks.

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The digital mapping and planning component 403 is a micro-processor based signal processing unit. The schematic functional block diagram is shown in Fig 10. The mapping and planning information will be sent out through RS232 or USB port.

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Fig 11 presents a typical installation on the bottom of a mobile vehicle. The mobile vehicle has four driving wheels 1101. The digital navigation unit 204 has been placed on the centre of the four driving wheels, as shown in Fig 11.

30 As shown in Fig 12, the needle wheels on three navigation units 203, 204 and 205 will be pressed on the ground by three springs 401, 402 and 403 with a

constant force, say 2kg. The needles on the needle wheels can prevent the slipping of the needle wheels and obtain correct information during the movement of the mobile vehicle.

- 5 The knowledge-based mapping and planning apparatus allows two ways to mapping and planning the navigation trajectories for a mobile vehicle or robot. One way is to move the vehicle or robot along an expected trajectory one time. The mapping and planning unit 403 will save the signals from three digital navigation units 203, 204 and 205 and then send the signals to the control
- 10 system of the vehicle or robot. Then the vehicle or robot could move on the same trajectory as many as time expected. Another way is mapping a trajectory based on known map on a building. In this way, the map information will be transferred to the digital navigation information.
- 15 The transformation of map information to digital navigation information could be done through variable algorithm. A simple algorithm is taking arithmetic mean of three navigation signals from three navigation units 203, 204 and 205 if the vehicle is moving along the trajectories 1301, 1302 and 1303 in Fig 13, respectively. Because the three trajectories for three navigation units in Fig 13
- 20 are straight lines, so the mean of signals from navigation units 203 and 204 should be equal to the mean of signals from navigation units 205 and 204.

For a curved trajectory, the three trajectories 1401, 1402 and 1403 with radius R1, R2 and R3, shown in Fig 14, will be transformed to perimeters of three

25 curves. Then the arithmetic mean will be applied to it. If the curve is along the same centre 1404 in Fig 14, the control system of the vehicle or robot will perform the three curves with radius R1, R2 and R3 in the same time frame.

Claims

1. An apparatus for mapping and planning a mobile vehicle or robot in
5 indoor environment, the apparatus comprising:
 - A navigation component comprises with several digital navigation units to collection navigation information from varies trajectories during the movement of a mobile vehicle or robot.
 - A position component comprises with several position units to identify
10 special targets for special tasks
 - A micro-processor based digital mapping and planning component comprises with an advanced signal processing unit, which provides the output in numerical format to RS232 or USB ports.
- 15 2. An apparatus according to claim 1, wherein the digital navigation units are fixed on a support plate with a known location to enable the calculation of the trajectory of the movement of the mobile vehicle or robot.
3. An apparatus according to claims 1 and 2, wherein the digital navigation
20 unit comprises one needle wheel or two needle wheels on the same shaft. The angle of needles on a needle wheel is fixed.
4. An apparatus according to claims 1 to 3, wherein the magnetic or optical encoder installed on the shaft of needle wheel/wheels is used to transform the
25 navigation information to digital one.
5. An apparatus according to claims 1 to 4, wherein the digital navigation units are guided by the ball splines or linear guides to limit them moving along one direction only.

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6. An apparatus according to claims 1 to 5, wherein the digital navigation units are pressed on the ground by spring during the movement of the mobile vehicle or robot.

5 7. An apparatus according to claim 1, wherein several position units are used to identify special targets for special tasks. The position unit is built by normal position sensors together with related circuits. These position units are fixed on the apparatus with known locations.

10 8. An apparatus according to claims 1 and 2, wherein the position unit is built by infra position sensors together with related circuits. These position units are fixed on the apparatus with known locations.

9. An apparatus according to claim 1, wherein a micro-processor based mapping and planning unit for signal processing and saving is built in the apparatus.

10. An apparatus according to claims 1 and 9, wherein the mapping and planning information is output through RS232 or USB port.

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11. An apparatus according to claims 1 to 10, wherein a knowledge-based mapping and planning algorithm is built in the mapping and planning unit.

12. An apparatus according to claims 1 to 11, wherein a knowledge-based mapping and planning algorithm provides two ways to map and plan the trajectory for the mobile vehicle and robot. One way is based on the knowledge of the trajectory of the mobile vehicle or robot taken before. Another way is based on the calculation of the planned trajectory in a building and the transformation among the trajectory and signals of the digital navigation units.

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13. An apparatus according to claims 1 to 12, wherein the apparatus can be installed on any mobile vehicle and robot to map and plan the navigation without any information from the area of navigation.
- 5 14. An apparatus according to claims 1 to 12, wherein the apparatus can be installed on any mobile vehicle and robot to map and plan the navigation without necessary to re-construction the building.