

Retro-fit Mobility Unit

Field of the Invention

The invention concerns a mobility unit for attaching to a hospital bed or trolley for improving the manoeuvrability of same in either an assisted or independent fashion. Typically the unit is used in a retro-fit or add-on manner and so is attached to an existing bed or trolley.

Background of the Invention

Healthcare is an industry in great need of efficient logistical solutions to improve the economic pressure to which it is currently exposed.

The transport of patients/materials/ food between different hospital wards and units is a time consuming and laborious task. As an example, the National University Hospital of Singapore alone employs an estimated 150 porters whose predominant job it is to move patients, materials and documents around the hospital.

Currently, it takes two persons (a nurse and a porter) to manually manoeuvre and transport a patient on a standard gurney/bed. Any shortage of porters can cause frequent delays in taking patients to an Operating room ("OR"), triggering a chain of delays in the patient care workflow and wasting valuable time for the groups of attending surgeons and nurses in the OR.

The invention transforms conventional, manually operated hospital beds and trolleys into powered systems that can be reliably moved and steered by fewer operators or, even, moved and steered independently of a human operator.

The retro-fit nature of the invention means the technology does not require the existing fleet of hospital beds and trolleys to be replaced. Moreover, advantageously, the invention also does not add to the footprint of current beds and trolleys, thus ensuring the existing, but limited, space in hospital corridors and elevators remains sufficient for ongoing use. Finally, reducing the number of staff needed to move hospital beds and trolleys will facilitate their redeployment in higher value tasks, which could lead to the provision of better healthcare and/or cost savings in the healthcare system.

Statements of the Invention

According to a first aspect of the invention there is provided a retro-fit mobility unit for attaching to a hospital bed or hospital trolley comprising a chassis having: i) a central

rectilinear frame; ii) at least one attachment member for attaching the chassis to the hospital bed or trolley; iii) a power supply; iv) at least two power driven wheel modules each one comprising a pair of aligned wheels rotatable about a shared central axel and wherein each wheel module is attached to the chassis by an off-set link rotatable about its vertical axis; and v) an associated control device for transferring power from said power supply to said wheel modules and for steering same in either a manual or programmed fashion.

In a preferred embodiment of the invention said chassis has a central rectilinear H-frame and, ideally, its cross-members are linked together using flexible hinges, thus enabling the unit to travel comfortably or relatively smoothly over uneven ground.

In yet a further preferred embodiment of the invention the dimensions, in particular the length, width and height of the chassis is such that it can fit under a conventional hospital bed or trolley without protruding from same or pressing against an item or items carried on same.

Additionally, the chassis is of an elongate nature. Most preferably, a wheel module is located at either end of the chassis.

In a preferred embodiment of the invention the wheel module comprises a pair of motors one for driving each wheel.

In yet a further preferred embodiment of the invention the chassis is, essentially, a symmetrical structure with an H-frame in the middle and a wheel module at either end.

In yet a further preferred embodiment a plurality of attachment members are provided and said attachment members are evenly distributed about said chassis, ideally, they are provided at or about each corner of the chassis H-frame.

In yet a further preferred embodiment of the invention said unit comprises at least one housing and, ideally, a housing at either end of said chassis. Most preferably said housings at either end of said chassis are the same, or substantially the same, whereby the chassis is symmetrical. More preferably still said housing(s) is/are adapted to accommodate on-board microcontrollers, power supply, electronics and batteries.

In yet a further preferred method of the invention said unit comprises an intuitive user control device comprising a panel of switches, a multi-direction joystick and a force/torque sensing unit.

- 5 According to a second aspect of the invention there is provided in, or for use in, a hospital bed or trolley, a retro-fit mobility unit comprising a chassis having: i) a central rectilinear frame; ii) at least one attachment member for attaching the chassis to the hospital bed or trolley; iii) a power supply; iv) at least two power driven wheel modules each one comprising a pair of aligned wheels rotatable about a shared central axel and wherein each
10 wheel module is attached to the chassis by an off-set link rotatable about its vertical axis; and v) an associated control device for transferring power from said power supply to said wheel modules and for steering same in either a manual or programmed fashion.

In an ideal embodiment of the invention said control device is intuitive and comprises a
15 panel of switches, a multi-direction joystick and a force/torque sensing unit.

According to a third aspect of the invention there is provided an intuitive user control device for use with a retro-fit mobility unit to be attached to, or attached to, a hospital bed or hospital trolley wherein said intuitive user control device comprises a panel of switches, a
20 multi-direction joystick and a force/torque sensing unit.

In a preferred embodiment of the invention said intuitive user control device is adapted for use with said retro-fit mobility unit and, ideally, comprises a computer program product adapted to perform one or more of the following methods:
25 manual control mode, augmented control mode, and an autonomous mode.

In the manual control mode, the user operates the bed through a handle attached to the force/torque sensing unit. A virtual dynamic model translates the forces applied by the human operator through the handle into motion commands in the three degrees of freedom
30 on a plane (two degrees of freedom of translational motion and one degree of freedom of rotation). The motion commands are further translated into control commands in the motors of the omni-directional wheels.

In the augmented control mode, the human operator sets control mode, selects a route and
35 the velocity through the control panel and the bed moves under the guidance of on-board

sensors, such as vision sensor – such as a camera - along the designated path. The user can override and change the control anytime.

In the autonomous mode, the user simply selects a route and the unit will move the bed or trolley from one place to another without human intervention. The implementation of this mode of use requires sensors on-board the system as well as sensors placed in the environment.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprises”, or variations such as “comprises” or “comprising” is used in an inclusive sense i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

All references, including any patent or patent application, cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. Further, no admission is made that any of the prior art constitutes part of the common general knowledge in the art.

Preferred features of each aspect of the invention may be as described in connection with any of the other aspects.

Other features of the present invention will become apparent from the following examples. Generally speaking, the invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including the accompanying claims and drawings). Thus, features, integers, characteristics, compounds or chemical moieties described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein, unless incompatible therewith.

Moreover, unless stated otherwise, any feature disclosed herein may be replaced by an alternative feature serving the same or a similar purpose.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is

used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

An embodiment of the present invention will now be described by way of example only with reference to the following wherein:

Figure 1 shows a perspective view of a hospital bed when fitted with the retro-fit mobility unit in accordance with the invention;

Figure 2 shows a perspective view of the retro-fit mobility unit in accordance with the invention;

Figure 3 shows a perspective view of the drive wheels of the retro-fit mobility unit and their associated mounting;

Figure 4 shows a side view of the drive wheels of the retro-fit mobility unit and their associated mounting;

Figure 5 shows a perspective view of the retro-fit mobility unit in accordance with the invention with the attachment members highlighted;

Figure 6 shows a side view of the retro-fit mobility unit in accordance with the invention;

Figure 7 shows an elevated perspective view of the retro-fit mobility unit in accordance with the invention with the control and power indicated;

Figure 8 shows an elevated perspective view of the retro-fit mobility unit in accordance with the invention with the batteries indicated;

Figure 9 shows a side view of a hospital trolley when fitted with the retro-fit mobility unit of the invention; and

Figure 10 shows a side view of a hospital trolley when fitted with the retro-fit mobility unit having an additional personnel platform.

The preferred mode of practice of this invention includes an retro-fit power assisted omni-directional mobility unit and an associated intuitive control unit.

Referring, firstly, to figures 5 and 6, there is shown a retro-fit mobility unit in accordance with the invention. It comprises a chassis having a central rectilinear H frame whose cross-members are linked together using conventional flexible hinges, thus enabling the unit to absorb and respond positively to torque forces generated as a result of travel over uneven ground. Notably the dimensions, in particular the length, width and height of the chassis is such that it can fit under a conventional hospital bed or hospital trolley without protruding from same or pressing against an item or items carried on same. Moreover, typically, the chassis is, in plan view, of an elongate nature. In the embodiment of the invention shown in the figures a wheel module is located at either end of the chassis, the wheel module is shown in greater detail in figures 3 and 4.

Referring now to figures 3 and 4, the wheel module comprises a pair of aligned wheels rotatable about a shared central axel and attached to the chassis by an off-set link positioned mid-way between the pair of wheels. The off-set link can, in turn, rotate about its central vertical axis. Each chassis is provided with at least two such wheel modules whereby the rigid chassis achieves omni-directional mobility. Although not shown, the pair of wheels are provided with a pair of motors one for driving each wheel. As shown in figures 3 and 4 a slip ring, for facilitating the transmission of power and electrical signals to a rotating structure, is provided. The omni-directional mobility units used in this invention are adopted from the invention disclosed in the US patent no. 6540,039 [1].

In an ideal embodiment of the invention, shown in figures 5 and 6, the chassis is essentially a symmetrical structure with a wheel module at either end and an H-frame in the middle.

The chassis is attached to a hospital bed or trolley using conventional adapters as shown in figure 5. Ideally, the adapters are evenly distributed about said chassis and in a preferred embodiment of the invention the adapters are provided at or about each corner of the chassis H-frame.

As shown in figures 7 and 8 the mobility unit is equipped with on-board microcontrollers, power supply, electronics and batteries. To facilitate this, a housing is provided and, ideally, the housing has an outer surface (and so is fashioned) to fit under the bed or trolley with which is it to be used. In the instance where the chassis is symmetrical the same housing is attached to either end of the chassis. Alternatively, although not shown, a single

housing may be attached to the chassis and this single housing is fashioned, ideally, but not exclusively to be symmetrical.

An intuitive user control device, which consists of a panel of switches, a multi-direction joystick, a force/torque sensing unit and a virtual dynamic model based control algorithm, is attached to one end of the bed, shown towards the left hand side of figure 9. The user control device design is based on force/torque sensing and the virtual dynamic model can be found in [3]. Briefly, the force/torque sensor detects the force applied by the user through the joystick/handle in the direction of intended movement, namely, the two: translational direction and the rotational direction. The force detected in each direction is input to a virtual model consisting of a mass and a damper in that direction to generate the moving speed in that direction. The mass and damper parameter are defined in such a way that the system behaves like a physical system and consists of the same mass and damper as defined, regardless of the actual physical mass and damping, thus giving the operator an intuitive control of the system. Using this unit, the bed can operate in three modes, namely, manual control mode, augmented control mode, and an autonomous mode.

In the manual control mode, the user operates the bed through the handle attached to the force/torque sensor. A virtual dynamic model translates the forces applied by the human operator through the joystick/handle into motion commands in the three degrees of freedom on a plane (two degrees of freedom of translational motion and one degree of freedom of rotation). The motion commands are further translated into control commands of the motors in the omni-directional mobility units. The motion control algorithm run on the microcontroller coordinates the motion of all the wheels to realize the omni-directional motion of the bed. The details of the motion control algorithms for this omni-directional mobility design can be found in [2]. Briefly, the basic working principle of the design is: each chassis will have at least two sets of wheel modules; each wheel module consists of two independently driven wheels with an offset link so that a command can control the motion at the rotation joint of the offset link in two directions; if the motions at any two points of a rigid chassis/platform can be controlled, the complete motion of the chassis/platform in all three directions on a plane can be realised, thus omni-directional mobility can be achieved. Therefore, a platform with at least two such wheel units can achieve omni-directional mobility.

In the augmented control mode, the human operator sets control mode, selects a route and the velocity through the control panel and the bed moves under the guidance of on-board sensors, such as vision sensor – shown as a camera mounted on the front housing in figure 9, along the designated path. The user can override and change the control anytime.

In the autonomous mode, the user simply selects a route and the system will go from one place to another without human intervention. The implementation of this mode of use requires sensors on-board the system as well as sensors placed in the environment.

Besides hospital beds, this invention can be applied to material transport trolleys in hospitals.

In summary, the invention provides the following advantages.

- a. Compared with existing manual hospital beds/trolleys, those fitted with the add-on unit of the invention can be operated by one single person with greatly reduced labor cost.
- b. The omni-directional mobility makes it very easy to manoeuvre beds/trolleys in narrow and congested corridors and wards, increasing the ergonomics and efficiency of the human operator.
- c. Compared with control methods such as button and joysticks, the intuitive control unit of the invention improves the ergonomics and reduces the cognitive burden for the user, reducing user error and further improving efficiency and productivity.
- d. There are currently no similar products on the market that can achieve powered omni-directional mobility for hospital beds with a retro-fit approach.
- e. There are currently no similar products on the market that can achieve powered omni-directional mobility for the material transport trolley with a retro-fit approach.

References

- [1]. Yu, H., Dubowsky, S., "Omni-directional Vehicle with Offset Wheel Pairs", United States Patent No. 6,540,039, April 1, 2003.
- [2]. Yu, H., Spenko, M., and Dubowsky, S. "Omni-Directional Mobility Using Active Split Offset Castors." ASME Journal of Mechanical Design, Vol. 126, No. 5, pp. 822-829, September 2004.
- [3]. Yu, H., Spenko, M., and Dubowsky, S. "An Adaptive Shared Control System for an Intelligent Mobility Aid for the Elderly." Autonomous Robots, Vol. 15, pp. 53-66, 2003.

Claims

1. A retro-fit mobility unit for attaching to a hospital bed or hospital trolley comprising a chassis having: i) a central rectilinear frame; ii) at least one attachment member for attaching the chassis to the hospital bed or trolley; iii) a power supply; iv) at least two power driven wheel modules each one comprising a pair of aligned wheels rotatable about a shared central axel and wherein each wheel module is attached to the chassis by an off-set link rotatable about its vertical axis; and v) an associated control device for transferring power from said power supply to said wheel modules and for steering same in either a manual or programmed fashion.
2. The unit according to claim 1 wherein said frame is an H-frame whose cross-members are linked together using flexible hinges.
3. The unit according to claim 1 or 2 wherein the dimensions of said chassis are such that it can fit under a conventional hospital bed or trolley without protruding from same or pressing against an item or items carried on same.
4. The unit according to any one of the preceding claims wherein a wheel module is located at either end of the chassis.
5. The unit according to any one of the preceding claims wherein each wheel module comprises a pair of motors one for driving each wheel.
6. The unit according to claim 5 wherein the chassis is, essentially, a symmetrical structure with an H-frame in the middle and a wheel module at either end.
7. The unit according to any one of the preceding claims wherein a plurality of attachment members are provided and said attachment members are evenly distributed about said chassis.
8. The unit according to claim 7 wherein said attachment members are provided at or about each corner of the chassis H-frame.
9. The unit according to any one of the preceding claims wherein said unit comprises at least one housing.
10. The unit according to claim 9 wherein said unit comprises, a housing at either end of said chassis.
11. The unit according to claims 9 or 10 wherein said housing is adapted to accommodate on-board microcontrollers, electronics, power supply and/or batteries.
12. The unit according to claims 10 or 11 wherein said housings at either end of said chassis are the same shape.

13. The unit according to any one of the preceding claims wherein said control device is intuitive and comprises a panel of switches, a multi-direction joystick and a force/torque sensing unit.

5 14. In, or for use in, a hospital bed or hospital trolley, a retro-fit mobility unit comprising a chassis having: i) a central rectilinear frame; ii) at least one attachment member for attaching the chassis to the hospital bed or trolley; iii) a power supply; iv) at least two power driven wheel modules each one comprising a pair of aligned wheels rotatable about a shared central axel and wherein each wheel module is attached to the chassis by an off-set link rotatable about its vertical axis; and v) an
10 associated control device for transferring power from said power supply to said wheel modules and for steering same in either a manual or programmed fashion.

15 15. An intuitive user control device for use with a retro-fit mobility unit according to any one of claims 1-14 wherein said intuitive user control unit comprises a panel of switches, a multi-direction joystick and a force/torque sensing unit.

15 16. A unit according to claim 15 wherein said intuitive user control device comprises a computer program product adapted to perform one or more of the following methods:

manual control mode, augmented control mode, and an autonomous mode.