

SYSTEM TO MONITOR USE AND OPERATION OF A LIFT

FIELD

This invention relates to a system to monitor use and operation of a lift.

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BACKGROUND

Lift monitoring and operating systems are currently available that enhance safety and ease of use of lifts provided with such systems. However, such systems are typically costly and complex to implement, often requiring complete replacement of old lifts and/or control system, and therefore out of the reach of many building owners or managers who are prohibited by cost and time from adopting such systems despite their advantages. Furthermore, as cities move towards smart operations, use of robots such as automated guided vehicles to perform unmanned deliveries is expected to increase, therefore requiring lifts to be also integrated within a smart city network. There is therefore a need to provide a cost-effective and readily implemented system for monitoring use and operation of lifts, that is compatible with other technological advances that are already available in smart cities around the world.

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SUMMARY

According to a first aspect, there is provided system to monitor use and operation of a lift controlled by a controller, the system comprising: a server; a BLE transceiver to automatically detect presence of a BLE beacon in the lift and to wirelessly provide presence data to the server; a load sensor to detect presence of a load in the lift and to determine a weight of the load, the load sensor having BLE transmission capability to wirelessly provide load data to the server; and at least one ride-quality sensor to detect at least one parameter that affects ride comfort in the lift, the at least one ride-quality sensor having BLE transmitting capability to wirelessly provide ride-quality data to the server; wherein the server is provided with associative functionality to associate the ride-quality data with the presence data and the load data.

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The server may be further provided with learning capability to learn from associated data and to optionally provide compensatory feedback derived from the associated data to the lift controller to adjust lift acceleration and velocity to improve ride quality for a detected load in the lift.

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The BLE transceiver may be configured to detect presence of more than one BLE beacon in the lift.

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The system may further comprise a door status sensor to obtain a door status of the lift, the system further configured to wirelessly transmit the door status to a status receiver in the lift, the status receiver being provided on a robotic user of the lift, the door status being one of: open and shut.

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The system may further comprise a floor level sensor to determine a floor level the lift may be at, the system further configured to wirelessly transmit the floor level data to the status receiver.

10 The system may further comprise a level displacement sensor to determine a vertical displacement between a carriage floor of the lift and a floor of a lift landing onto which the lift door opens, the system further configured to wirelessly transmit the vertical displacement data to the status receiver.

15 The system may further comprise a rope condition sensor to monitor condition of a suspension wire rope of the system, the rope condition sensor having BLE transmitting capability to wirelessly provide rope condition data to the server.

20 The at least one ride-quality sensor may comprise an accelerometer to detect acceleration, velocity, deceleration and jerk of the lift.

The at least one ride-quality sensor may comprise a vibration sensor to determine vibration frequency and vibration intensity experienced by the load in the lift.

25 The at least one ride-quality sensor may comprise a sound sensor to detect noise level in the lift.

Presence data in the server may be made available to a location tracking service for tracking location and movement of the BLE beacon.

30 The BLE transceiver may be configured as a node of a BLE mesh network provided in a building in which the lift may be installed.

35 The server may be further provided with a lift-controlling application to send a signal to the lift controller to move the lift to a lift lobby when a node of the BLE mesh network provided at the lift lobby detects presence of the BLE beacon at the lift lobby for a predetermined minimum period of time.

The lift-controlling application may be further configured to send a signal to the lift controller to move the lift to a specific floor when destination data stored in the BLE beacon is obtained by the BLE transceiver and transmitted to the server.

5 **BRIEF DESCRIPTION OF FIGURES**

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

10 FIG. 1 is a schematic illustration of an exemplary system for monitoring use and operation of a lift.

DETAILED DESCRIPTION

Exemplary embodiments of a system 10 to monitor use and operation of a lift will be described
15 below with reference to FIG. 1.

In an exemplary embodiment, as shown in FIG. 1, the system 10 to monitor use and operation of a lift 99 is configured to be retrofitted on a lift 99 that is operated via a lift controller 100. The lift controller 100 controls movement of the lift 99 between different floors in a building 200 according to input provided to the lift 99 by a user 80. The user 80 may be a person, or the user
20 80 may be a robot, the term “robot” in this application being defined as a machine capable of carrying out a complex series of actions automatically. Thus, automated guided vehicles such as those used in hospitals are included under the definition of the term “robot” as used in this application, as are any other unmanned forms of conveyance that may use the lift 99 when
25 moving from one location to another in the building 200.

The system 10 comprises a Bluetooth® Low Energy (BLE) transceiver 20 that is to be provided on the lift 99 to automatically detect presence of a BLE beacon 29 in the lift 99 by receiving data transmitted by the BLE beacon 29 via Bluetooth® and to wirelessly transmit this presence data
30 to a server 30 of the system 10. In an exemplary embodiment, the BLE transceiver 20 may be configured as a node of a BLE mesh network 109 in connection with the server 30, the mesh network 109 being provided in the building 200 in which the lift 99 is installed, so that movement of the BLE beacon 29 anywhere within the building 200 can be automatically detected and tracked, including when the BLE beacon 29 is in the lift 99. In an alternative embodiment, the
35 BLE transceiver 20 may comprise a BLE gateway that receives data via Bluetooth® and sends

data via GSM to the server 30.

In exemplary embodiments of use, the BLE beacon 29 may be attached to a user 80 or a package 90 or both. In this application, the term “package” is used to refer to goods or documents or any other items that are to be securely delivery to a location in the building 200. Thus, at any point in time, it can be understood that a load in the lift 99 will comprise one or more users 80, and may or may not include one or more packages 90. The ability to detect presence of such packages 90 in the lift 99 via the BLE transceiver 20 enhances location tracking and security of these packages 90.

Depending on circumstances, the BLE beacons 29 may already be attached to a user 80 or a package 90 before arrival of the user 80 or package 90 at the building 200, or BLE beacons 29 may be provided at the building 200 for attachment to users 80 and packages 90 upon their arrival. Users 80 of the lift 99 may include persons or even animals such as pets whose movements are desired to be kept track of. For example, such persons may include young children or those with limited abilities, whether physical or mental, who may require assistance getting from one place to another correctly and safely. It would thus be in the interest of safety of these persons to monitor their locations. In other examples, a user 80 may comprise a delivery person or delivery robot.

Notably, the BLE transceiver 20 is configured to operate with more than one BLE beacon 29 at a time so that presence of multiple BLE beacons 29 in the lift 99 can be detected. For example, a user 80 provided with a first BLE beacon 29 and a package 90 attached with a second BLE beacon 29 being delivered by the user 80 (as shown in FIG. 1) can both be detected to be in the lift 99 when the delivery person 80 bearing the package 90 takes the lift 99 to a delivery address in the building 200. In this way, presence and tracking of users 80 and packages 90 within the building 200, including within the lift 99, can be performed.

To further facilitate detection of the presence of a load in the lift 99, the system 10 also comprises a load sensor 40 that is to be provided on the lift 99 and configured to detect presence of the load in the lift 99 by detecting a weight of the load in the lift 99 and to transmit this load data to the server 30. The load sensor 40 is preferably provided with BLE transmitting capability to allow wireless transmission of data from the lift 99 to the server 30. In an exemplary embodiment, load data from the load sensor 40 may be transmitted to the server 30 via the BLE transceiver 20 in the same way as presence data from a BLE beacon 29 is transmitted to the server 30. Load data

from the load sensor 40 can be used to validate presence of a load in the lift 99 that may already have been detected by the BLE transceiver 20 from a BLE beacon 29 attached to the load, and also to provide indication of the type of load in the lift 99 according to the weight of the load that has been sensed by the load sensor 40. The load sensor 40 also serves as an alternative
5 detector of presence of a load in the lift 99 in situations where no BLE beacon 29 is attached to the load, as such loads without BLE beacons attached will not be detected by the BLE transceiver 20. In an exemplary embodiment, the load sensor 40 may comprise a plurality of compression load cells provided in an evenly distributed configuration under the lift carriage floor 12, i.e., between the lift carriage floor 12 and an external frame 14 of the lift 99.

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To improve ride comfort for users of the lift 99, the system 10 may further comprise one or more ride-quality sensors to be provided on the lift 99 to detect parameters that affect ride comfort in the lift 99 such as acceleration, deceleration, jerks, vibration, noise level etc. Such ride quality sensors are preferably provided with BLE receiving and transmitting capability to wirelessly
15 provide their respective sensed ride-quality data to the server 30 via the BLE transceiver 20 in the same way as presence data from a BLE beacon 29 is provided to the server 30. For example, the one or more ride-quality sensors comprised in the system 10 may include an accelerometer 61 to detect acceleration, velocity, deceleration and any jerks experienced by the lift 99 during lift movement, a vibration sensor 62 to detect frequency and intensity of vibrations during lift
20 movement and opening / closing of the lift door, a sound sensor 63 to detect noise level in the lift 99, and so on.

To continually improve ride quality of the lift 99, ride-quality data obtained by the one or more ride-quality sensors may be associated with presence data obtained by the BLE transceiver 20
25 and load data obtained by the load sensor 40, so that ride-quality data can be associated with different conditions of use of the lift 99. Examples of the different conditions include: (a) when presence of a load in the lift 99 has been detected by at least one of the BLE transceiver 20 and the load sensor 40, and (b) in the absence of any load in the lift 99. In this way, ride quality for lift users 80 may be more realistically obtained and tracked as the additional weight (detected by
30 the load sensor 40) of the users 80 in the lift 99 would affect the acceleration, vibration and noise levels in the lift 99, while the ride-quality data obtained during absence of a load in the lift 99 can serve as a control or background level for comparison. The server 30 may accordingly be provided with associative functionality to associate the ride-quality data with the presence data and the load data. The server 30 may further be provided with learning capability (e.g. a neural
35 network) to learn from associated data in order to optionally provide compensatory feedback

- derived from the associated data to the lift controller 100 (as indicated by the arrow 31) to adjust lift acceleration and velocity, so as to improve ride quality for a detected load in the lift 99, for example, by minimizing vibration, jerk and noise in the lift 99. It should be noted that providing compensatory feedback to the lift controller 100 is an optional functionality of the server 30 that
- 5 may or may not be actually implemented, depending on the configurability of the lift controller 100 or the purpose of providing the system 10 on the lift 99. For example, the system 10 may be provided on the lift 99 only to facilitate and monitor movement of users 80 and packages 90 in the lift 99 without requiring compensatory feedback to be transmitted to the lift controller 100.
- 10 The system 10 may further comprise a door status sensor 70 that is to be provided on the lift 99 to obtain a door status (i.e. open or shut) of the lift 99 of the lift 99 (not shown). The door status sensor 70 is configured to wirelessly transmit the door status to a status receiver 72 in the lift. In an exemplary embodiment of use, the status receiver 72 may be provided on a robotic user 80 that takes the lift 99, so that when the robotic user 80 is in the lift, the robotic user 80 will
- 15 automatically move out of the lift 99 only upon the status receiver 72 receiving a signal from the door status sensor 70 that the lift door is open. In an exemplary embodiment, the door status sensor 70 may comprise a current sensor to measure electrical current of a door motor of the lift 99 for determining door status.
- 20 In addition to the door status sensor 70, the system 10 may also comprise a floor level sensor 74 that is to be provided on the lift 99 to detect which floor the lift 99 is currently at. The floor level sensor 74 is configured to wirelessly transmit floor level data to the status receiver 72 in the lift so that the robotic user 80 will automatically move out of the lift 99 only upon the status receiver 72 receiving a signal from the door status sensor 70 that the lift door is open and a signal from
- 25 the floor level sensor 74 confirming that the lift 99 has arrived at the desired floor level for the robotic user 80. This is to avoid the robotic user 80 exiting the lift 99 when the lift door opens at another floor that has been selected by another user that may be taking the same lift as the robotic user 80. In an exemplary embodiment, the floor level sensor 74 may comprise a laser distance sensor provide at a top or bottom surface of the lift 99 to detect distance between the top or
- 30 bottom surface of the lift 99 and a ceiling or floor of the lift shaft respectively.

In addition to the floor level sensor 74, the system 10 may further comprise a level displacement sensor 76 that is to be provided on the lift 99 to determine a vertical displacement (if any) between the lift carriage floor 12 and the floor of the lift landing 202 onto which the lift door

35 opens. The level displacement sensor 76 may be configured to wirelessly transmit the vertical

displacement data to the status receiver 72 so that the robotic user 80 will automatically move out of the lift 99 only when the status receiver 72 receives: a signal from the door status sensor 70 that the lift door is open, a signal from the floor level sensor 74 that the lift 99 has arrived at the desired floor level for the robotic user 80, and a signal from the level displacement sensor 76 that the vertical displacement between the lift carriage floor 12 and the floor of the lift landing 202 is within a predetermined value that is safe for the robotic user 80 to move over. This ensures that the robotic user 80 can safely move out of the lift 99 onto the lift landing 202 without toppling due to uneven floor levelling between the lift carriage floor 12 and the floor of the lift landing 202. The level displacement sensor 76 may also be configured to emit a warning sound if the vertical displacement is determined to be greater than a predetermined value, so that human users 80 can be forewarned to step with care when exiting the lift 99. In an exemplary embodiment, the level displacement sensor 76 may comprise a laser displacement sensor.

In alternative embodiments, the door status sensor 70, floor level sensor 74 and level displacement sensor 76 may be provided with BLE receiving and transmitting capability to wirelessly provide their respective obtained data to the server 30 via the BLE transceiver 20 in the same way as presence data from a BLE beacon 29 is provided to the server 30. The status receiver 72 may accordingly be configured to receive data obtained by the door status sensor 70, floor level sensor 74 and level displacement sensor 76 wirelessly from the server 30 to determine whether or not the robotic user 80 should exit the lift 99.

To further improve safety for users of the lift 99, the system 10 may further comprise a rope condition sensor 50 through which a suspension wire rope 16 of the lift 99 is to be passed. The rope condition sensor 50 monitors the condition of the wire rope 16 by detecting any deterioration that may have arisen in the rope 16. Rope deterioration may include loss of metal due to wear, corrosion and/or breakage of individual strands that form the rope 16. In an exemplary embodiment, the rope condition sensor 50 may comprise a magnetic flux leakage sensor 50 that detects flux leakages caused by deterioration defects in the rope 16 as the rope 16 passes through the sensor 50. The rope condition sensor 50 is preferably provided with BLE transmitting capability to wirelessly provide rope condition data to the server 30 in the same way as presence data from a BLE beacon 29 is provided to the server 30. In an exemplary embodiment, data from the rope condition sensor 50 may be wirelessly transmitted to the server 30 via the BLE transceiver 20 in the same way as presence data from a BLE beacon 29 is provided to the server 30. The rope condition sensor 50 is preferably decoupled from the lift controller so as not to interfere with normal operation of the lift and to allow ready retrofitting of the rope condition

sensor 50 onto existing lifts.

Notably, the system 10 as described above is in general decoupled from the lift controller 100 and can function in isolation from the lift controller 100. In this way, installing the system 10 on an existing lift 99 may be readily performed without requiring costly and time consuming modifications to the lift controller 100 as there is no need to integrate functionalities of the system 10 with the lift controller 100. This also allows existing lifts to be efficiently and cost-effectively retrofitted with the system 10 without affecting their lift controllers 100.

Data provided to the server 30 may also serve as evidence of presence and movement of users 80 and packages 90 within the building 200. In this way, the system 10 can function to confirm safe arrival of secured packages 90 to specific addresses in the building 200.

Example of Use

In an envisaged example of use, a user 80 such as a delivery robot may be delivering a package 90 to a unit on a tenth floor of a building 200, the user 80 and package 90 each being already provided with a BLE beacon 29. Before the user 80 and package 90 arrive at the building 200, movement of the user 80 and package 90 are tracked by an external location tracking system (not shown).

Upon arrival at the building 200, location of the user 80 and package 90 are tracked via a BLE mesh network 109 of the building 200. Preferably, each lift lobby in the building 200 is provided with a BLE node of the BLE mesh network 109 in order to detect presence of BLE beacons 29 at each lift lobby. The server 30 may be provided with a lift-controlling application (not shown) in connection with the BLE mesh network 109 as well as the lift controller 100. The lift-controlling application is activated to call a lift to the lift lobby upon the BLE node at the lift lobby detecting a BLE beacon 29 being present for a predetermined minimum period of time at the lift lobby. A predetermined minimum period of time is used to determine that a user 80 bearing a BLE beacon 29 is waiting for a lift at the lift lobby, as opposed to the user 80 bearing the BLE beacon 29 merely arriving at a lift lobby upon exiting a lift as a user 80 exiting the lift 99 would not linger at the lift lobby but move away from the lift lobby towards its destination in the building 200. When activated to call a lift, the lift-controlling application sends a signal to the lift controller 100 (as indicated by the arrow 31) to move a lift 99 to the lift lobby. In this way, when a user 80 and/or package 90 provided with a BLE beacon 29 is detected to be present at a lift lobby for a predetermined minimum period of time, a lift 99 is automatically sent to that

lift lobby without requiring a lift call button to be pressed, which is particularly useful for robotic users 80.

5 Upon the user 80 and package 90 entering the lift 99, the BLE transceiver 20 of the presently disclosed system 10 detects presence of the BLE beacons 29 of the user 80 and package 90 and sends their presence data to the server 30. Destination data (such as the floor and unit number in the building 200 to which the package 90 is to be delivered) may be stored in the BLE beacons 29 of the user 80 and package 90 so that, in addition to the BLE transceiver 20 detecting presence of the BLE beacons 29 on the user 80 and package 90, the destination data is also obtained by
10 the BLE transceiver 20 and transmitted to the server 30. The lift-controlling application is consequently activated to send a signal to the lift controller 100 (as indicated by the arrow 31) to move the lift 99 to the correct floor of the destination without requiring the robotic user 80 to press a button in the lift 99 for the desired floor.

15 When the lift 99 arrives at the correct floor for the robotic user 80, the robotic user 80 will exit the lift 99 only when a status receiver 72 of the robotic user 80 receives data obtained by the lift door status sensor 70 confirming that the lift door is open, data obtained by the floor level sensor 74 confirming that the lift 99 has arrived at the desired floor level for the robotic user 80, and data obtained by the level displacement sensor 76 confirming that the vertical displacement
20 between the lift carriage floor 12 and the floor of the lift landing 202 is within a predetermined value that is safe for the robotic user 80 to move over. In this way, a robotic user 80 can arrive at the building 200 and take the lift 99 up to a desired floor without requiring the robotic user 80 or a person to call for the lift 99 or select a floor for the robotic user 80.

25 It should be noted that data in the server 30 may also optionally be made available to other location tracking services (not shown) to track movement of the user 80 and package 90, including when the user 80 and package 90 are in the lift 99 and to confirm eventual delivery of the package 90 to the destination unit.

30 The above-disclosed system 10 thus provides a cost-effective and readily implemented system to monitor use and operation of lifts 99 by all kinds of users 80, and to track the movement of packages 90 within the lifts 99 of buildings 200. By being configured to be retrofitted to existing lifts 99, the system 10 allows older lifts 99 to become modernized and compatible with modern technology present in smart cities, such as other location tracking systems that track and confirm
35 the movement and location of users 80 and packages 90 outside and within the building 200.

Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations and combination in details of design, construction and/or operation may be made
5 without departing from the present invention.

CLAIMS

1. A system to monitor use and operation of a lift controlled by a controller, the system comprising:
 - 5 a server;
 - a BLE transceiver to automatically detect presence of a BLE beacon in the lift and to wirelessly provide presence data to the server;
 - a load sensor to detect presence of a load in the lift and to determine a weight of the load, the load sensor having BLE transmission capability to wirelessly provide
 - 10 load data to the server, wherein the load data provides indication of type of load in the lift; and
 - at least one ride-quality sensor to detect at least one parameter that affects ride comfort in the lift, the at least one ride-quality sensor having BLE transmitting capability to wirelessly provide ride-quality data to the server;
 - 15 wherein the server is provided with associative functionality to associate the ride-quality data with the presence data and the load data, and wherein the server is further provided with learning capability to learn from associated data and to optionally provide compensatory feedback derived from the associated data to the lift controller to adjust lift acceleration and velocity to improve ride quality for a
 - 20 detected load in the lift.
2. The system of claim 1, wherein the BLE transceiver is configured to detect presence of more than one BLE beacon in the lift.
- 25 3. The system of any one of the preceding claims, further comprising a door status sensor to obtain a door status of the lift, the system further configured to wirelessly transmit the door status to a status receiver in the lift, the status receiver being provided on a robotic user of the lift, the door status being one of: open and shut.
- 30 4. The system of claim 3, further comprising a floor level sensor to determine a floor level the lift is at, the system further configured to wirelessly transmit the floor level data to the status receiver.
5. The system of claim 3 or claim 4, further comprising a level displacement sensor to
- 35 determine a vertical displacement between a carriage floor of the lift and a floor of a lift

landing onto which the lift door opens, the system further configured to wirelessly transmit the vertical displacement data to the status receiver.

- 5 6. The system of any one of the preceding claims, further comprising a rope condition sensor to monitor condition of a suspension wire rope of the system, the rope condition sensor having BLE transmitting capability to wirelessly provide rope condition data to the server.
- 10 7. The system of any one of the preceding claims, wherein the at least one ride-quality sensor comprises an accelerometer to detect acceleration, velocity, deceleration and jerk of the lift.
8. The system of any one of the preceding claims, wherein the at least one ride-quality sensor comprises a vibration sensor to determine vibration frequency and vibration intensity experienced by the load in the lift.
- 15 9. The system of any one of the preceding claims, wherein the at least one ride-quality sensor comprises a sound sensor to detect noise level in the lift.
- 20 10. The system of any one of the preceding claims, wherein presence data in the server is made available to a location tracking service for tracking location and movement of the BLE beacon.
11. The system of any one of the preceding claims, wherein the BLE transceiver is configured as a node of a BLE mesh network provided in a building in which the lift is installed.
- 25 12. The system of claim 11, wherein the server is further provided with a lift-controlling application to send a signal to the lift controller to move the lift to a lift lobby when a node of the BLE mesh network provided at the lift lobby detects presence of the BLE beacon at the lift lobby for a predetermined minimum period of time.
- 30 13. The system of claim 12, wherein the lift-controlling application is further configured to send a signal to the lift controller to move the lift to a specific floor when destination data stored in the BLE beacon is obtained by the BLE transceiver and transmitted to the server.