[0003] However, the movement assistance apparatus uniformly consumes electric power to recognize the surrounding environment regardless of the magnitude of a surrounding risk on the movement of the user (for example, approach of a vehicle). Therefore, the power consumption is large and the period that elapses before exhaustion of the remaining power storage amount of a battery is relatively short. When the remaining power storage amount of the battery is exhausted, the movement assistance apparatus cannot perform the operation described above (movement assistance operation such as notification for avoiding collision with a moving object).

[0004] By increasing the size of the battery to be mounted, it is possible to continuously exert the function over a long period. In this case, however, the size and weight of the battery increase, which leads to a lack of practicality. Power saving can be achieved and the battery can be downsized when the user switches the power supply of the movement assistance apparatus ON and OFF as necessary. However, the power ON/OFF operation is cumbersome and the function cannot be exerted when the power ON operation is neglected. Thus, the function cannot reliably be exerted at appropriate timings.

[0005] The present invention provides a movement assistance apparatus and a movement assistance system that enhance practicality in power saving.

[0006] A movement assistance apparatus according to a first aspect of the present invention is a movement assistance apparatus to be provided in a movement assistance device and configured to execute a movement assistance operation for assisting movement of a user. The movement assistance apparatus includes a mode switching control unit configured to switch, based on a magnitude of a surrounding risk on the movement of the user, a power mode between a normal mode in which the movement assistance operation is executable and a power saving mode in which a power consumption is smaller than a power consumption in the normal mode. A condition for setting the power mode to the power saving mode includes a condition that the surrounding risk satisfies a predetermined low-risk condition. The movement assistance apparatus also includes a risk index acquisition unit configured to acquire a risk index correlated to the magnitude of the surrounding risk on the movement of the user. The surrounding risk satisfies the predetermined low-risk condition when the risk index acquired by the risk index acquisition unit is equal to or smaller than a predetermined

threshold. The surrounding risk is related to approaches of one or more vehicles to the user. The risk index acquisition unit includes: one or more resonance devices configured to resonate with sounds emitted by the one or more vehicles approaching the user; one or more power generation devices configured to generate electric power along with resonances of the one or more resonance devices; and one or more detection devices configured to detect physical quantities related to power generations of the one or more power generation devices. The surrounding risk satisfies the predetermined low-risk condition when each of the physical quantities detected by the one or more detection devices is equal to or smaller than a predetermined threshold.

[0007] The phrase "a power consumption is smaller than a power consumption in the normal mode" may be a concept including a case where the power consumption is zero.

[0008] When the surrounding risk on the movement of the user is relatively high (does not satisfy the predetermined low-risk condition), the mode switching control unit may set the power mode of the movement assistance apparatus to the normal mode under that condition, thereby enabling the movement assistance operation for assisting the movement of the user. When the surrounding risk on the movement of the user is relatively low and satisfies the predetermined low-risk condition, the power mode of the movement assistance apparatus may set to the power saving mode and the electric power consumed by the movement assistance apparatus may be zero under satisfaction of a predetermined condition including the condition that the surrounding risk satisfies the predetermined low-risk condition (including a case of only the condition that the surrounding risk satisfies the predetermined low-risk condition). Alternatively, the electric power consumed by the movement assistance apparatus may be reduced. Thus, the power mode may be set to the normal mode as necessary so that the movement assistance operation can be executed, and the power mode may be set to the power saving mode when the movement assistance operation is not necessary, thereby reducing the power consumption of the movement assistance apparatus. As a result, the function of the movement assistance apparatus (function of performing the movement assistance operation at appropriate timings) may be exerted continuously over a long period without the need to mount a large-size battery, thereby enhancing the practicality in the power saving of the movement assistance apparatus.

[0009]

[0010] When the risk index is larger than the predetermined threshold, it may be assumed that the surrounding risk on the movement of the user is relatively high. Under the condition that the risk index is larger than the predetermined threshold, the mode switching control unit may set the power mode of the movement assistance apparatus to the normal

mode, thereby enabling the movement assistance operation for assisting the movement of the user. When the risk index is equal to or smaller than the predetermined threshold, it may be assumed that the surrounding risk on the movement of the user is relatively low. Under satisfaction of a predetermined condition including the condition that the risk index is equal to or smaller than the predetermined threshold, the power mode of the movement assistance apparatus may be set to the power saving mode and the electric power consumed by the movement assistance apparatus may be zero. Alternatively, the electric power consumed by the movement assistance apparatus may be reduced. In this case as well, the power mode may be set to the normal mode as necessary so that the movement assistance operation can be executed, and the power mode may be set to the power saving mode when the movement assistance operation is not necessary, thereby reducing the power consumption of the movement assistance apparatus. By switching the power mode based on the comparison between the risk index and the predetermined threshold, it may be possible to easily set the condition for switching the power mode.

[0011]

[0012] The user may recognize that the vehicle is approaching the user and the surrounding risk on the movement of the user increases by using the operation of resonance of the resonance device with the sound emitted by the vehicle (including a sound generated as the vehicle travels). That is, the resonance device may resonate with the sound emitted by

a system management server configured to transmit and receive information to and from the movement assistance apparatus, the communication unit being configured to transmit switching command information for the power saving mode to the movement assistance apparatus under satisfaction of a predetermined condition including a condition that a surrounding risk satisfies a predetermined low-risk condition, a mode switching control unit provided in the movement assistance apparatus and configured to switch the power mode to the power saving mode when the switching command information is received from the communication unit, and a risk index provided in the movement assistance apparatus and configured to acquire a risk index correlated to the magnitude of the surrounding risk on the movement of the user. The surrounding risk satisfies the predetermined low-risk condition when the risk index acquired by the risk index acquisition unit is equal to or smaller than a predetermined threshold. The surrounding risk is related to approaches of one or more vehicles to the user. The risk index acquisition unit includes: one or more resonance devices configured to resonate with sounds emitted by the one or more vehicles approaching the user; one or more power generation devices configured to generate electric power along with resonances of the one or more resonance devices; and one or more detection devices configured to detect physical quantities related to power generations of the one or more power generation devices. The surrounding risk satisfies the predetermined low-risk condition when each of the physical quantities detected by the one or more detection devices is equal to or smaller than a predetermined threshold.

[0046] When the surrounding risk on the movement of the user is relatively high, the mode switching control unit of the movement assistance apparatus may set the power mode to the normal mode under that condition, thereby enabling the movement assistance operation for assisting the movement of the user. When the surrounding risk on the movement of the user is relatively low and satisfies the predetermined low-risk condition, the switching command information for the power saving mode may be transmitted to the movement assistance apparatus from the communication unit of the system management server under satisfaction of the predetermined condition including the condition that the surrounding risk satisfies the predetermined low-risk condition. In the movement assistance

apparatus that has received the switching command information, the mode switching control unit may set the power mode to the power saving mode, and the electric power consumed by the movement assistance apparatus may be reduced to zero. Alternatively, the electric power consumed by the movement assistance apparatus may be reduced. Thus, in the movement assistance system according to the second aspect of the present invention, the power mode may be set to the normal mode as necessary so that the movement assistance operation can be executed, and the power mode may be set to the power saving mode when the movement assistance operation is not necessary, thereby reducing the power consumption of the movement assistance apparatus.

[0047] In the present invention, for the switching of the power mode based on the magnitude of the surrounding risk on the movement of the user, the condition for setting the power mode to the power saving mode may include the condition that the surrounding risk

CLAIMS

1. A movement assistance apparatus to be provided in a movement assistance device and configured to execute a movement assistance operation for assisting movement of a user, the movement assistance apparatus characterized by comprising:

a mode switching control unit configured to switch, based on a magnitude of a surrounding risk on the movement of the user, a power mode between a normal mode in which the movement assistance operation is executable and a power saving mode in which a power consumption is smaller than a power consumption in the normal mode, wherein a condition for setting the power mode to the power saving mode includes a condition that the surrounding risk satisfies a predetermined low-risk condition; and

a risk index acquisition unit configured to acquire a risk index correlated to the magnitude of the surrounding risk on the movement of the user, wherein the surrounding risk satisfies the predetermined low-risk condition when the risk index acquired by the risk index acquisition unit is equal to or smaller than a predetermined threshold,

wherein:

the surrounding risk is related to approaches of one or more vehicles to the user;

the risk index acquisition unit includes:

one or more resonance devices configured to resonate with sounds emitted by the one or more vehicles approaching the user;

one or more power generation devices configured to generate electric power along with resonances of the one or more resonance devices; and

one or more detection devices configured to detect physical quantities related to power generations of the one or more power generation devices; and

the surrounding risk satisfies the predetermined low-risk condition when each of the physical quantities detected by the one or more detection devices is equal to or smaller than a predetermined threshold.

2. The movement assistance apparatus according to claim 1, wherein the sounds emitted by the one or more vehicles include at least one of an approach notification sound, a siren sound of an emergency vehicle, or a traveling sound of a train.

3. The movement assistance apparatus according to claim 1 or 2, wherein a resonance frequency of each of the one or more resonance devices is set as a frequency higher than a frequency of the sound emitted by a corresponding one of the one or more vehicles by an amount corresponding to frequency shift due to a Doppler effect when the corresponding one of the one or more vehicles approaches the user.

4. The movement assistance apparatus according to any one of claims 1 to 3, wherein:

the movement assistance device includes a grip portion to be gripped by the user; and

a plurality of the resonance devices is arranged at a plurality of positions in the grip portion, and resonance frequencies of the resonance devices are individually set based on frequencies of sounds of the vehicles that emit the sounds at different frequencies.

5. The movement assistance apparatus according to claim 4, wherein:

the grip portion of the movement assistance device includes a plurality of contact areas where fingers of a hand of the user come into contact; and

the resonance devices are arranged at positions corresponding to the contact areas different from each other.

6. The movement assistance apparatus according to claim 4 or 5, further comprising:

a plurality of switches arranged in association with arrangement positions of the resonance devices and configured to be pressed by the user; and

a notification device configured to receive a press signal from at least one of the switches pressed by the user, identify the one or more vehicles approaching the user based on the at least one of the switches that has issued the press signal, and perform a user presence notification operation for the one or more vehicles.

7. The movement assistance apparatus according to claim 1, wherein the magnitude of the surrounding risk on the movement of the user is correlated to an urgency level that is based on a physical period that elapses before the user faces danger during the movement of the user.

8. The movement assistance apparatus according to claim 7, wherein the urgency level is a level corrected, based on at least one of urgency level correction parameters during the movement of the user, from a reference urgency level associated with the physical period that elapses before the user faces the danger during the movement of the user.

9. The movement assistance apparatus according to claim 8, wherein the urgency level correction parameters include at least one of an agility of avoidance action of the user against an event that the user faces the danger during the movement of the user, an ease of avoidance action of the user depending on a surrounding environment against the event that the user faces the danger during the movement of the user, or a type of the danger during the movement of the user.

10. The movement assistance apparatus according to claim 1, wherein the magnitude of the surrounding risk on the movement of the user is correlated to an importance level that is a level of influence resulting from an event that the user faces danger during the movement of the user.

11. The movement assistance apparatus according to any one of claims 1 to 10, wherein whether the surrounding risk satisfies the predetermined low-risk condition is determined

based on at least one of user's periphery information acquired by an information acquisition device provided in the movement assistance apparatus, information received from an external device by the movement assistance apparatus, or position information of the movement assistance device.

12. The movement assistance apparatus according to any one of claims 1 to 11, wherein the mode switching control unit is configured to switch the power mode from the power saving mode to the normal mode when the surrounding risk satisfies a predetermined high-risk condition from a state in which the surrounding risk satisfies the predetermined low-risk condition.

13. The movement assistance apparatus according to any one of claims 1 to 6, wherein the mode switching control unit is configured to switch the power mode from the power saving mode to the normal mode when the risk index acquired by the risk index acquisition unit is larger than the predetermined threshold from a state in which the risk index is equal to or smaller than the predetermined threshold.

14. The movement assistance apparatus according to any one of claims 1 to 13, wherein the movement assistance apparatus in the power saving mode is in a sleep state in which power supply to a device built in the movement assistance apparatus is stopped.

15. The movement assistance apparatus according to any one of claims 1 to 14, further comprising a storage unit configured to store information on a situation in which the movement assistance operation is necessary, wherein the mode switching control unit is configured to switch the power mode to the normal mode when the user who is moving is in the situation stored in the storage unit in which the movement assistance operation is necessary.

16. The movement assistance apparatus according to claim 15, wherein the mode switching control unit is configured to switch the power mode by checking information on a current area around the user based on a trained model generated from the information stored in the storage unit on the situation in which the movement assistance operation is necessary.

17. The movement assistance apparatus according to any one of claims 1 to 16, wherein the movement assistance device is gripped or carried by the user.

18. A movement assistance system characterized by comprising:

a movement assistance apparatus provided in a movement assistance device and configured to execute a movement assistance operation for assisting movement of a user, and switch a power mode between a normal mode in which the movement assistance operation is executable and a power saving mode in which a power consumption is smaller than a power consumption in the normal mode;

a communication unit provided in a system management server configured to transmit and receive information to and from the movement assistance apparatus, the communication unit being configured to transmit switching command information for the power saving mode to the movement assistance apparatus under satisfaction of a predetermined condition including a condition that a surrounding risk satisfies a predetermined low-risk condition;

a mode switching control unit provided in the movement assistance apparatus and configured to switch the power mode to the power saving mode when the switching command information is received from the communication unit; and

a risk index acquisition unit provided in the movement assistance apparatus and configured to acquire a risk index correlated to the magnitude of the surrounding risk on the movement of the user, wherein the surrounding risk satisfies the predetermined low-risk condition when the risk index acquired by the risk index acquisition unit is equal to or smaller than a predetermined threshold,

wherein:

the surrounding risk is related to approaches of one or more vehicles to the user;

the risk index acquisition unit includes:

one or more resonance devices configured to resonate with sounds emitted by the one or more vehicles approaching the user;

one or more power generation devices configured to generate electric power along with resonances of the one or more resonance devices; and

one or more detection devices configured to detect physical quantities related to power generations of the one or more power generation devices; and

the surrounding risk satisfies the predetermined low-risk condition when each of the physical quantities detected by the one or more detection devices is equal to or smaller than a predetermined threshold.