Claims

1. A guide-rail track vehicle comprising:
a car body; and
a bogie configured to support the bottom of the car body,
wherein the bogie includes
a car body tilting mechanism configured to tilt the car body in a vehicle lateral direction;
a guiding frame configured to turn while being guided by guide rails provided along a track;
a detection unit configured to detect the degree of turning of the guiding frame; and
a tilt control unit configured to control the car body tilting mechanism to tilt the car body based on a detection result from the detection unit,
wherein the detection unit includes
a link mechanism which is configured to convert a displacement of the guiding frame in a turn direction into a linear displacement, and
a displacement sensor which is fixed to a floor surface of the car body or a suspension frame attached to the car body, and which is configured to detect the linear displacement converted by the link mechanism.

2. The guide-rail track vehicle according to claim 1,
wherein the link mechanism is configured to convert the displacement of the guiding frame in the turn direction into a vertical displacement.

3. The guide-rail track vehicle according to claim 1 or 2, further comprising:
dampening apparatuses that are disposed between the bogie and the car body while being separate from each other in the vehicle lateral direction;
a height adjustment apparatus configured to be able to individually adjust the height of each of the dampening apparatuses; and
an automatic height adjustment mechanism configured to maintain the height of the dampening apparatus in a pre-set range of height by operating the height adjustment apparatus,
wherein the car body tilting mechanism includes a height adjustment apparatus moving mechanism configured to be able to move the height adjustment apparatus in a height direction, and a drive apparatus configured to drive the height adjustment apparatus moving mechanism, and
wherein the tilt control unit controls the driving of the drive apparatus based on a detection result from the detection unit, and moves the position of the height adjustment apparatus in the height direction using the height adjustment apparatus moving mechanism.

4. The guide-rail track vehicle according to claim 1 or 2, further comprising:
dampening apparatuses that are disposed between the bogie and the car body while being separate from each other in the vehicle lateral direction;

a height adjustment apparatus configured to be able to individually adjust the height of each of the dampening apparatuses; and

an automatic height adjustment mechanism configured to maintain the height of the dampening apparatus in a pre-set range of height by operating the height adjustment apparatus,

wherein the car body tilting mechanism includes a tilt angle control apparatus that is configured to change the height of the dampening apparatus while bypassing the height adjustment apparatus, when tilting the car body, and a tilt adjustment apparatus configured to restrict the height adjustment apparatus from adjusting the height of the dampening apparatus, and

wherein the tilt control unit controls the driving of the tilt angle control apparatus based on a detection result from the detection unit such that the height of the dampening apparatus is adjusted.

5. The guide-rail track vehicle according to claim 1 or 2, further comprising:

dampening apparatuses that are disposed between the bogie and the car body while being separate from each other in the vehicle lateral direction;

a height adjustment apparatus configured to be able to individually adjust the height of each of the dampening apparatuses; and

an automatic height adjustment mechanism configured to maintain the height of the dampening apparatus in a pre-set range of height by operating the height adjustment apparatus,

wherein the car body tilting mechanism includes a car body lifting up and down apparatus that is configured to support the bottom of the dampening apparatus and to be able to move the position of the dampening apparatus in a vertical direction, and a tilt adjustment apparatus configured to restrict the height adjustment apparatus from adjusting the height of the dampening apparatus, and

wherein the tilt control unit controls the car body lifting up and down apparatus to displace the position of the dampening apparatus in the vertical direction based on a detection result from the detection unit.

6. The guide-rail track vehicle according to claim 1 or 2, further comprising:

dampening apparatuses that are disposed between the bogie and the car body while being separate from each other in the vehicle lateral direction; and

an anti-rolling apparatus that is configured to include a torsion bar extending in the vehicle lateral direction, and to restrict the tilting of the car body using a restoring force of the torsion bar in a torsional direction,

wherein the car body tilting mechanism includes a rod expansion and contraction apparatus configured to displace a neutral position of the torsion bar in the torsional direction, and

wherein the tilt control unit controls the driving of the rod expansion and contraction apparatus based on a detection result from the detection unit such that the neutral position of the torsion bar is displaced.

7. The guide-rail track vehicle according to claim 5 or 6, further comprising:

dampening apparatuses that are disposed between the bogie and the car body while being separate from each other in the vehicle lateral direction,

wherein the bogie includes a suspension frame fixed to a floor portion of the car body,

wherein the car body tilting mechanism includes a right/left stopper that is disposed in a lateral center portion of the floor portion of the car body and is configured to restrict the car body from being slid in the vehicle lateral direction while allowing the car body to be tilted in the vehicle lateral direction, and a car body tilting drive apparatus configured to apply force to the suspension frame in the vehicle lateral direction, and

wherein the tilt control unit controls the driving of the car body tilting drive apparatus based on a detection result from the detection unit such that force is applied to the suspension frame in the vehicle lateral direction.

8. The guide-rail track vehicle according to any one of claims 1 to 7,

wherein the tilt control unit includes

a running condition acquisition unit configured to acquire at least vehicle speed information as a running condition;

a curvature radius calculation unit configured to calculate the curvature radius of the track based on the degree of turning detected by the detection unit;

a normal acceleration calculation unit configured to obtain normal lateral acceleration applied to passengers in the vehicle based on the vehicle speed information and the curvature radius; and

a tilt angle calculation unit configured to calculate the lateral tilt angle of the car body based on the normal lateral acceleration.

9. The guide-rail track vehicle according to claim 8, further comprising:

a speed detection unit configured to detect a vehicle speed,

wherein the running condition acquisition unit acquires vehicle speed information from the speed detection unit, and

wherein the normal acceleration calculation unit calculates normal lateral acceleration based on information regarding the vehicle speed and the curvature radius.

10. The guide-rail track vehicle according to claim 8, further comprising:

a storage unit configured to pre-store information regarding the cant of the track and the vehicle speed,

wherein the running condition acquisition unit acquires information regarding the cant and the vehicle speed from information stored in the storage unit, and

wherein the normal acceleration calculation unit calculates normal lateral acceleration based on information regarding the cant, the vehicle speed, and the curvature radius.

11. The guide-rail track vehicle according to claim 10, further comprising:

an acceleration detection unit configured to detect normal lateral acceleration,

wherein the running condition acquisition unit acquires information regarding the normal lateral acceleration detected by the acceleration detection unit, and

wherein the tilt control unit includes an acceleration comparison unit that is configured to compare the normal lateral acceleration calculated by the normal acceleration calculation unit with the normal lateral acceleration detected by the acceleration detection unit.

12. A car body tilt control method of a guide-rail track vehicle according to any one of claims 1 to 11, the method comprising:

a detection step of detecting the degree of turning of the guiding frame; and

a tilt control step of controlling the tilting of a car body based on the degree of turning of the guiding frame.

13. The car body tilt control method of a guide-rail track vehicle according to claim 12,

wherein the tilt control step includes

a running condition acquisition step of acquiring at least vehicle speed information as a running condition;

a curvature radius calculation step of calculating the curvature radius of the track based on the degree of turning of the guiding frame;

a normal acceleration calculation step of obtaining normal lateral acceleration applied to passengers in the vehicle based on the vehicle speed and the curvature radius; and

a tilt angle calculation step of calculating the lateral tilt angle of the car body based on the normal lateral acceleration, and

wherein the tilting of the car body is controlled in such a manner that the tilt angle is equal to the calculated tilt angle.

14. The car body tilt control method of a guide-rail track vehicle according to claim 13,

wherein information regarding a cant and the vehicle speed is acquired in the running condition acquisition step, and

wherein the normal lateral acceleration is calculated based on the cant, the vehicle speed, and the curvature radius in the normal acceleration calculation step.

15. The car body tilt control method of a guide-rail track vehicle according to claim 14, further comprising:

an acceleration detection step of detecting normal lateral acceleration,

wherein information regarding the normal lateral acceleration detected in the acceleration detection step is acquired in the running condition acquisition step, and

wherein the tilt control step includes an acceleration comparison step of comparing the normal lateral acceleration calculated in the normal acceleration calculation step with the normal lateral acceleration detected in the acceleration detection step.

16. The guide-rail track vehicle according to any one of claims 1 to 11,

wherein the bogie includes:

a pair of travelling wheels which are disposed in a vehicle lateral direction of the car body; and

a bogie frame having a kingpin that rotatably supports the pair of travelling wheels, and

wherein the pair of travelling wheels are steered by using the turning of the guiding frame.

CLAIMS

1. A guide-rail track vehicle comprising:

a car body;

a bogie configured to support the bottom of the car body, and

dampening apparatuses that are disposed between the bogie and the car body,

wherein the bogie includes

a car body tilting mechanism configured to tilt the car body in a vehicle lateral direction;

a guiding frame configured to turn while being guided by guide rails provided along a track;

a detection unit configured to detect the degree of turning of the guiding frame; and

a tilt control unit configured to control the car body tilting mechanism to tilt the car body based on a detection result from the detection unit,

wherein the detection unit includes

a link mechanism which is configured to convert a displacement of the guiding frame in a turn direction into a linear displacement, and

a displacement sensor which is fixed to a floor surface of the car body or a suspension frame attached to the car body, and which is configured to detect the linear displacement converted by the link mechanism,

wherein the link mechanism is configured to convert the displacement of the guiding frame in the turn direction into a displacement in a direction toward the displacement sensor.

2. The guide-rail track vehicle according to claim 1,

wherein the link mechanism is configured to convert the displacement of the guiding frame in the turn direction into a vertical displacement.

3. The guide-rail track vehicle according to claim 1 or 2,

wherein the link mechanism includes:

a horizontal rod which is coupled to a cross beam of the guiding frame so as to extend in the vehicle lateral direction, and which is configured to be capable of swinging with respect to the guiding frame,

a horizontal detection link which is configured to be capable of swinging with respect to the horizontal rod, and which is supported by the car body so as to be capable of turning about an axial line extending in an longitudinal direction of the car body, and

a vertical rod which is configured to be capable of swinging with respect to the horizontal detection link, and which is formed to extend in a vertical direction; and

wherein the displacement sensor is configured to detect an amount of a vertical displacement of the vertical rod as a linear displacement.

4. The guide-rail track vehicle according to any one of claims 1 to 3, further comprising:

a height adjustment apparatus configured to be able to individually adjust the height of each of the dampening apparatuses; and

an automatic height adjustment mechanism configured to maintain the height of the dampening apparatus in a pre-set range of height by operating the height adjustment apparatus,

wherein the car body tilting mechanism includes a height adjustment apparatus moving mechanism configured to be able to move the height adjustment apparatus in a height direction, and a drive apparatus configured to drive the height adjustment apparatus moving mechanism, and

wherein the tilt control unit controls the driving of the drive apparatus based on a detection result from the detection unit, and moves the position of the height adjustment apparatus in the height direction using the height adjustment apparatus moving mechanism.

5. The guide-rail track vehicle according to any one of claims 1 to 3, further comprising:

a height adjustment apparatus configured to be able to individually adjust the height of each of the dampening apparatuses; and

an automatic height adjustment mechanism configured to maintain the height of the dampening apparatus in a pre-set range of height by operating the height adjustment apparatus,

wherein the car body tilting mechanism includes a tilt angle control apparatus that is configured to change the height of the dampening apparatus while bypassing the height adjustment apparatus, when tilting the car body, and a tilt adjustment apparatus configured to restrict the height adjustment apparatus from adjusting the height of the dampening apparatus, and

wherein the tilt control unit controls the driving of the tilt angle control apparatus based on a detection result from the detection unit such that the height of the dampening apparatus is adjusted.

6. The guide-rail track vehicle according to any one of claims 1 to 3, further comprising:

a height adjustment apparatus configured to be able to individually adjust the height of each of the dampening apparatuses; and

an automatic height adjustment mechanism configured to maintain the height of the dampening apparatus in a pre-set range of height by operating the height adjustment apparatus,

wherein the car body tilting mechanism includes a car body lifting up and down apparatus that is configured to support the bottom of the dampening apparatus and to be able to move the position of the dampening apparatus in a vertical direction, and a tilt adjustment apparatus configured to restrict the height adjustment apparatus from adjusting the height of the dampening apparatus, and

wherein the tilt control unit controls the car body lifting up and down apparatus to displace the position of the dampening apparatus in the vertical direction based on a detection result from the detection unit.

7. The guide-rail track vehicle according to any one of claims 1 to 3, further comprising:

an anti-rolling apparatus that is configured to include a torsion bar extending in the vehicle lateral direction, and to restrict the tilting of the car body using a restoring force of the

torsion bar in a torsional direction,

wherein the car body tilting mechanism includes a rod expansion and contraction apparatus configured to displace a neutral position of the torsion bar in the torsional direction, and

wherein the tilt control unit controls the driving of the rod expansion and contraction apparatus based on a detection result from the detection unit such that the neutral position of the torsion bar is displaced.

8. The guide-rail track vehicle according to claim 6 or 7,

wherein the car body tilting mechanism includes a right/left stopper that is disposed in a lateral center portion of the floor portion of the car body and is configured to restrict the car body from being slid in the vehicle lateral direction while allowing the car body to be tilted in the vehicle lateral direction, and a car body tilting drive apparatus configured to apply force to the suspension frame in the vehicle lateral direction, and

wherein the tilt control unit controls the driving of the car body tilting drive apparatus based on a detection result from the detection unit such that force is applied to the suspension frame in the vehicle lateral direction.

9. The guide-rail track vehicle according to any one of claims 1 to 8,

wherein the tilt control unit includes

a running condition acquisition unit configured to acquire at least vehicle speed information as a running condition;

a curvature radius calculation unit configured to calculate the curvature radius of the track based on the degree of turning detected by the detection unit;

a normal acceleration calculation unit configured to obtain normal lateral acceleration applied to passengers in the vehicle based on the vehicle speed information and the curvature radius; and

a tilt angle calculation unit configured to calculate the lateral tilt angle of the car body based on the normal lateral acceleration.

10. The guide-rail track vehicle according to claim 9, further comprising:

a speed detection unit configured to detect a vehicle speed,

wherein the running condition acquisition unit acquires vehicle speed information from the speed detection unit, and

wherein the normal acceleration calculation unit calculates normal lateral acceleration based on information regarding the vehicle speed and the curvature radius.

11. The guide-rail track vehicle according to claim 9, further comprising:

a storage unit configured to pre-store information regarding the cant of the track and the vehicle speed,

wherein the running condition acquisition unit acquires information regarding the cant and the vehicle speed from information stored in the storage unit, and

wherein the normal acceleration calculation unit calculates normal lateral acceleration based on information regarding the cant, the vehicle speed, and the curvature radius.

12. The guide-rail track vehicle according to claim 11, further comprising:

an acceleration detection unit configured to detect normal lateral acceleration,

wherein the running condition acquisition unit acquires information regarding the normal lateral acceleration detected by the acceleration detection unit, and

wherein the tilt control unit includes an acceleration comparison unit that is configured to compare the normal lateral acceleration calculated by the normal acceleration calculation unit with the normal lateral acceleration detected by the acceleration detection unit.

13. A car body tilt control method of a guide-rail track vehicle according to any one of claims 1 to 12, the method comprising:

a detection step of detecting the degree of turning of the guiding frame; and

a tilt control step of controlling the tilting of a car body based on the degree of turning of the guiding frame.

14. The car body tilt control method of a guide-rail track vehicle according to claim 13,

wherein the tilt control step includes

a running condition acquisition step of acquiring at least vehicle speed information as a running condition;

a curvature radius calculation step of calculating the curvature radius of the track based on the degree of turning of the guiding frame;

a normal acceleration calculation step of obtaining normal lateral acceleration applied to passengers in the vehicle based on the vehicle speed and the curvature radius; and

a tilt angle calculation step of calculating the lateral tilt angle of the car body based on the normal lateral acceleration, and

wherein the tilting of the car body is controlled in such a manner that the tilt angle is equal to the calculated tilt angle.

15. The car body tilt control method of a guide-rail track vehicle according to claim 14,

wherein information regarding a cant and the vehicle speed is acquired in the running condition acquisition step, and

wherein the normal lateral acceleration is calculated based on the cant, the vehicle speed, and the curvature radius in the normal acceleration calculation step.

16. The car body tilt control method of a guide-rail track vehicle according to claim 15, further comprising:

an acceleration detection step of detecting normal lateral acceleration,

wherein information regarding the normal lateral acceleration detected in the acceleration detection step is acquired in the running condition acquisition step, and

wherein the tilt control step includes an acceleration comparison step of comparing the normal lateral acceleration calculated in the normal acceleration calculation step with the normal lateral acceleration detected in the acceleration detection step.

17. The guide-rail track vehicle according to any one of claims 1 to 12,
wherein the bogie includes:
a pair of travelling wheels which are disposed in a vehicle lateral direction of the car body; and
a bogie frame having a kingpin that rotatably supports the pair of travelling wheels, and
wherein the pair of travelling wheels are steered by using the turning of the guiding frame.