Title: WHEEL ASSEMBLY AND ASSOCIATED INPUT DEVICE

Abstract: Embodiments of the subject matter described herein provide a wheel assembly and an associated input device. The wheel assembly comprises a magnet and a wheel including a core that is capable of magnetically interacting with the magnet. The wheel assembly further comprises a lever such that a distance between the magnet and the wheel can be adjusted by rotating the magnet with rotation of the lever. This arrangement may provide at least two operation modes. When the magnet is far away from the wheel such that the wheel experiences a small resistance, the user may freely roll the wheel, and when the magnet approaches the wheel such that the wheel experiences a great resistance, the user may perform a typical or fine scrolling operation.

Declarations under Rule 4.17:
— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))
— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(in))

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WHEEL ASSEMBLY AND ASSOCIATED INPUT DEVICE

BACKGROUND

[0001] The mouse is one of the most commonly used input devices. A traditional mouse may be provided with a mouse wheel. When a user is rolling the mouse wheel forward or backward, the content such as a page on the computer display may be scrolled or switched to help the user to view the content. Generally, the traditional mouse wheel has only one operation mode, so it would be impossible or inconvenient for the user to adjust its rolling resistance. However, when the user is operating the mouse, it is necessary to provide different operation modes according to different situations or different user preferences to the rolling resistance. Usually, the traditional mouse wheel cannot provide such choices. Even if such choices are provided in some traditional mouse, the user experience may be adversely impacted to some extent. Similar problems are also present for other types of input devices.

SUMMARY

[0002] Embodiments of the subject matter described herein provide a wheel assembly for use in a mouse or another input device. The wheel assembly comprises a magnet and a wheel that is provided with a core capable of magnetically interacting with the magnet. The wheel assembly further comprises a lever such that a distance between the magnet and the wheel can be adjusted by rotating the magnet with rotation of the lever. By way of the arrangement, at least two operation modes may be provided, in which a hyper mode is provided when the magnet is far away from the wheel such that the wheel experiences such a small resistance that may be even neglected. In the hyper mode, the user may freely roll the wheel. When the magnet approaches the wheel, the wheel experiences a great resistance, thus providing a resistance mode. In the resistance mode, the user may perform a typical or fine scrolling operation. As a result, the embodiments of the subject matter described herein may be adapted to different situations and thus offer a good user experience.

[0003] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.
BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Through the more detailed description of some example embodiments of the subject matter described herein taken in connection with the accompanying drawings, the above and other objects, features and advantages of the subject matter described herein will become more apparent. The same reference signs generally denote the same components in the example embodiments of the subject matter described herein.

[0005] FIG. 1 illustrates a cross-sectional view of a wheel assembly according to an example embodiment of the subject matter described herein;

[0006] FIG. 2 illustrates a cross-sectional view of the wheel assembly as shown in FIG. 1 in another operation mode;

[0007] FIG. 3a illustrates a perspective view of the wheel assembly as shown in FIG. 1;

[0008] FIG. 3b illustrates a perspective view of a torsion spring according to an embodiment of the subject matter described herein;

[0009] FIG. 4a illustrates a side view of an example arrangement of a magnet according to an embodiment of the subject matter described herein;

[0010] FIG. 4b illustrates another side view of the example arrangement of the magnet as shown in FIG. 4a;

[0011] FIG. 5a illustrates a cross-sectional view of a part of a wheel assembly according to an embodiment of the subject matter described herein;

[0012] FIG. 5b illustrates a side view of a part of a wheel assembly according to an embodiment of the subject matter described herein;

[0013] FIG. 5c illustrates a side view of a part of a wheel assembly according to an embodiment of the subject matter described herein;

[0014] FIG. 5d illustrates a diagram illustrating an interaction area of the wheel assembly as shown in FIG. 5b;

[0015] FIG. 5e illustrates a diagram illustrating an interaction area of the wheel assembly as shown in FIG. 5c; and

[0016] FIG. 6 illustrates a flowchart of an example method of producing a wheel assembly according to an embodiment of the subject matter described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] The subject matter described herein will now be discussed with reference to several embodiments. It should be understood these embodiments are discussed only for the purpose of enabling those skilled persons in the art to better understand and thus implement the subject matter described herein, rather than suggesting any limitations on
the scope of the subject matter.

[0018] As used herein, the term "includes" and its variants are to be read as open terms that mean "includes, but is not limited to." The term "or" is to be read as "and/or" unless the context clearly indicates otherwise. The term "based on" is to be read as "based at least in part on." The term "one embodiment" and "an embodiment" are to be read as "at least one embodiment." The term "another embodiment" is to be read as "at least one other embodiment." The terms "first," "second," and the like may refer to different or same objects. Other definitions, explicit and implicit, may be included below.

[0019] The following description may relate to some specific numerical values or numerical ranges. It should be understood that these numerical values and numerical ranges are only illustrative, and may help bring the ideas of the subject matter described herein into practice. However, the description of these examples is by no means intended to limit the scope of the subject matter described herein. According to the specific situations and requirements, these numerical values or numerical ranges may be set otherwise.

[0020] As described above, the traditional mouse wheel usually has only one operation mode, so it is impossible or inconvenience for the user to adjust its rolling resistance. However, when the user is operating the mouse, it is necessary to provide different operation modes according to different situations or different user preferences to the rolling resistance. Usually, the traditional mouse wheel cannot provide such choices.

[0021] The embodiments of the subject matter described herein provide a wheel assembly applicable to an input device such as a mouse, which at least in part solves the above problem. In the following, reference is first made to FIGS. 1-2, which illustrate cross-sectional views of the wheel assembly 100 in different operation modes according to an example embodiment of the subject matter described herein.

[0022] As shown in FIGS. 1 and 2, the wheel assembly 100 described here generally comprises a wheel 10 and a magnet 20 that is disposed on a rotation plane of the wheel 10. In some embodiments, the magnet 20 is a permanent magnet. The wheel 10 comprises a core 15 that is capable of magnetically interacting with the magnet 20. The core 15 may be produced from a soft magnetic material which is easily magnetized and demagnetized, and the core 15 may be an iron core, for example.

[0023] The distance between the magnet 20 and the wheel 10 can be adjusted to change the rolling resistance of the wheel 10, thereby adjusting the magnetic interaction or the magnetic force between the magnet 20 and the core 15. For example, in the case that the
distance between the magnet 20 and the wheel 10 is relatively great, the attraction between the magnet 20 and the core 15 is relatively weak and can even be neglected. In this mode, the wheel can be rolled quickly to facilitate the quick scroll-up/down operation, for example. When the distance between the magnet 20 and the wheel 10 is relatively small or the two are even pressed against each other, the attraction between the magnet 20 and the core 15 is relatively great and thus a great resistance is applied to the wheel 10 to facilitate a typical or fine rolling operation, for example.

[0024] In certain embodiments, in order to more effectively adjust the distance between the magnet 20 and the wheel 10, the wheel assembly 100 may further comprise a lever 60. The lever 60 is coupled to the magnet 20 and enables the magnet 20 to rotate with the rotation of the lever 60. As shown in FIG. 1, the lever 60 is provided with a rotation shaft 75 and may be rotated around the shaft. In the embodiment as shown in FIG. 1, the magnet 20 may be supported by a holder 65 and may be fixed via the holder 65 to one end of the lever 60. The holder 65 and/or the lever 60 may be made of a plastic material. For example, the holder 65 and the lever 60 may each be integrally formed by injection molding.

[0025] Due to the magnetic attraction between the magnet 20 and the core 15, the end of the lever 60 including the magnet 20 may be attracted to the wheel 10. In that case, the magnet 20 and the wheel 10 are substantially pressed against each other. In order to adjust the distance between the magnet 20 and the wheel 10, in some embodiments, the wheel assembly 100 may further comprise a mechanism for adjusting the rotation state of the lever 60. In the embodiment as shown in FIG. 1, this mechanism may comprise a torsion spring 55 and a cam 45. The torsion spring 55 is operable to apply a torsional force to the lever 60 to counteract or overcome the magnetic force between the magnet 20 and the core 15. Correspondingly, the cam 45 is operable to counteract or overcome the torsional force applied by the torsion spring 55 to the lever 60. It is noted that, other mechanisms may be used to adjust the rotation state of the lever 60, although the adjustment mechanism in which the torsion spring 55 and the cam 45 cooperate with each other is illustrated here. For example, a brake may be used to adjust the rotation state of the lever 60. In an alternative embodiment, the magnetic force between the magnet 20 and the wheel 10 may be used to attract the magnet 20 to the wheel 10, and the brake holds the magnet 20 away from the wheel 10.

[0026] As shown in FIG. 1, a connector 70 is fixed to the holder 65 via a thread fitting and then is connected to the lever 60. The connector 70 is pressed against the cam 45,
and may be used as a follower of the cam 45. The cam 45 can adjust by its own rotation the pushing force applied to the connector 70, and thus the pushing force applied to the lever 60. It is noted that, although the connector 70 is fixed to the holder 65 by a thread fitting in the embodiment as shown in FIG. 1, other fittings such as a snap may be used, or the connector 70 may be even formed integrally with the holder 65.

[0027] In the following, the change of the state of the wheel assembly 100 will be described with reference to FIGS. 1-2. As shown in FIG. 1, the cam 45 is in a first state of applying a force that is directed towards the wheel 10 to the connector 70 and thus to the magnet 20, so as to counteract or overcome the torsional force applied by the torsion spring 55 to the magnet 20, thereby pushing the magnet 20 to approach the wheel 10. In the example embodiment as shown in FIG. 1, the distance between the magnet 20 and the wheel 10 is very small and may be substantially neglected. At this time, there is the strongest magnetic force between the magnet 20 and the core 15. For the sake of convenience, the position of the magnet 20 is called "a first position." In this state, the wheel 10 has a relatively great rolling resistance and thus provides a relatively fine controlling mode.

[0028] In some cases, for example, for a quick scrolling operation, the user may need to quickly roll the wheel. At this time, applying a great resistance to the wheel may result in a very poor user experience. In this case, the rolling resistance should be reduced as much as possible. To this end, the cam 45 may be in a second state, as shown in FIG. 2, when the torsional force of the torsion spring 55 counteracts or overcomes the magnetic force between the magnet 20 and the core 15 to push the magnet 20 to move away from the wheel 10. For the sake of convenience, this position of the magnet 20 is called "a second position." At the second position, the distance between the magnet 20 and the core 15 is so far that the magnetic force can be considered to be zero. In this way, the wheel 10 could be rotated freely and quickly.

[0029] During the switching from the first position to the second position, the cam 45 may be first rotated to the second state. As such, the torsion spring 55 may counteract or overcome the magnetic force between the magnet 20 and the core 15 to push the lever 60 to allow the magnet to arrive at the second position. During the switching from the second position to the first position, the cam 45 may be first switched to the first state, and the cam 45, during the rotation, gradually counteracts or overcomes the torsional force applied by the torsion spring 55 to push the magnet 20 to approach the wheel 10, so that the magnet 20 is switched to the first position.
In order to adjust the state of the cam 45, in some embodiments, the wheel assembly 100 may be provided with a motor 50, as shown in FIG. 1. The motor 50 may rotate by a predetermined angle in response to a user's input and thus change the state of the cam 45. For example, the wheel assembly 100 or the associated input device may be provided with a button (not shown) for switching on or off the motor 50. For example, when the user presses the button, the motor 50 may rotate by the predetermined angle, and the cam 45 is switched from the first state to the second state. When the user presses the button again, the motor 50 may rotate by the predetermined angle, and the cam 45 is switched from the second state to the first state. It is noted that the motor 50 is not an essential component, and in an alternative embodiment, other actuation mechanisms may be used or the state of the cam 45 may be adjusted manually.

In the following, an example connection of the torsion spring 55 will be described in more detail. FIG. 3a illustrates a perspective view of the wheel assembly 100 as shown in FIG. 1; and FIG. 3b illustrates a perspective view of a torsion spring 55 in relaxed state according to an embodiment of the subject matter described herein.

As shown in FIG. 3b, the torsion spring 55 includes a first end 550, a second end 551 and a spiral portion 552 between the two ends. As shown in FIGS. 1, 2, and 3a, the spiral portion 552 is sheathed on the rotation shaft of the lever 60, the first end 550 is fixed to a frame 25, and the second end 551 is fixed to the lever 60. As described above, in the example embodiments as shown in FIGS. 1-2, the torsion spring 55 is in a torsional state to apply the torsional force to the lever 60. The cam 45 or the motor 50 has to overcome the torsional force of the torsion spring 55 to push the magnet 20 from the second position to the first position. Correspondingly, the torsion spring 55 has to overcome the magnetic force to push the magnet 20 from the first position to the second position.

FIGS. 4a and 4b illustrate a magnet 20 according to an example embodiment of the subject matter described herein. FIG. 4a illustrates a cross-sectional view of the magnet 20 in the rotation plane of the wheel 10 and FIG. 4b illustrates a view of the magnet 20 as seen from the wheel 10. As shown in FIG. 4a, the magnet 20 is a Halbach array, and the magnet 20 includes three magnets 210, 220, and 230, where "N" and "S" represent the north pole and the south pole for each magnet, respectively. It should be understood that the magnet 20 may include any other suitable numbers of magnets.

The Halbach array is a permanent magnet that has a strong magnetic field at one side of the array and an almost zero magnetic field at the other side. Thus, the magnet 20 may be arranged such that the side having a strong magnetic field faces the wheel 10 to
provide a strong magnetic field to the core 15, thereby providing a strong magnetic
interaction. In the example arrangement as shown in FIG. 4a, the left side of the magnet
20 (corresponding to the north pole side of the magnet 220) has a strong magnetic
field, while the right side of the magnet 20 (corresponding to the south pole side of the magnet
220) has a weak or substantially zero magnetic field.

[0035] It should be understood that the magnet 20 may be arranged in other manners.
For example, if the north and south poles of the magnets 210 and 230 are reversed, the
right side of the magnet 20 (corresponding to the south pole side of the magnet 220) has a
strong magnetic field, while the left side of the magnet 20 (corresponding to the north pole
of the magnet 220) has a weak or substantially zero magnetic field. Additionally, in the
example arrangement as shown in FIG. 4a, at the left side of the magnet 20, the magnetic
field at the magnet 220 extends substantially outward from the north pole of the magnet
220, and the magnetic field at the magnets 210 and 230 extends substantially in parallel
with the left side of the magnet 20.

[0036] Now referring back to FIG. 1, in some embodiments, the wheel assembly 100
may further include adjustment means (30, 35, 40) that is operable to enable the magnet 20
to rotate substantially perpendicularly to the rotation plane of the wheel 10, thereby
adjusting the magnetic force between the magnet 20 and the core 10. This enables an
additional adjustment to the rolling resistance of the wheel 10. In the embodiment as
shown in FIG. 1, the adjustment means (30, 35, 40) includes an adjustment wheel 30 and
an engagement mechanism including a first gear 35 and a second gear 40. The
adjustment wheel 30 may rotate in response to a user's input. The engagement
mechanism is coupled to the adjustment wheel 30 and the magnet 20, and operable to
enable the magnet 20 to rotate substantially perpendicularly to the rotation plane of the
wheel 10 in response to the rotation of the adjustment wheel 30, thereby adjusting the
angle of the magnet 20 with respect to the wheel 10.

[0037] As shown in FIG. 1, the first wheel 35 is coupled to the adjustment wheel 30, and
operable to rotate coaxially with the adjustment wheel 30. The second gear 40 is
engaged with the first gear 35 and fixed to the magnet 20, and operable to adjust the angle
of the magnet 20 with respect to the wheel 10. The adjustment wheel 30 may be rotated
by a user's finger. Then, the first gear 35 rotates coaxially with the adjustment wheel 30,
and the motion is transferred to the second gear 40 by means of gear cooperation. Then,
the magnet holder 65 rotates with the second gear 40. The magnet 20 is arranged in the
holder 65, and thus rotates synchronously with the holder 65.
[0038] In the following, the adjustment of the angle between the magnet 20 and the wheel 10 will be described in detail with reference to FIGS. 5a-5e. FIG. 5a illustrates a cross-sectional view of a part of the wheel assembly 100 as shown in FIG. 1: FIG. 5b illustrates a side view of the part of the wheel assembly 100 as shown in FIG. 5a; FIG. 5c illustrates a side view of the part of the wheel assembly 100 as shown in FIG. 5a in another state; and FIGS. 5d and 5e illustrate interaction areas between the magnet 20 and the core 15 in the states as shown in FIGS. 5b and 5c, respectively. The magnet 20 as shown in FIGS. 5a and 5b is the Halbach array as shown in FIGS. 4a and 4b. However, it should be understood that the same principle is applicable to other magnets. For example, the Halbach array as shown in FIGS. 5a-5c may be replaced by the single magnet 220 only.

[0039] As shown in FIG. 5a, when the magnet 20 is disposed in the first position, the magnet 20 is substantially pressed against the wheel 10 and the gap between them is quite small. In some embodiments, the core 15 is a disk coaxially with the wheel 10. The edge of the core 15 is provided with a plurality of teeth 155, and a respective recess is formed between two adjacent teeth 155.

[0040] The magnet 20 may be positioned to produce a magnetic field substantially facing the rotation shaft of the wheel 10. In the case that that the magnet 20 is replaced by a single magnet, for example, the Halbach array as shown is replaced by the magnet 220, magnetic field lines may extend from the north pole of the magnet 220 towards the rotation shaft of the wheel 10. The cross-section of the magnetic field may have a substantially rectangular shape, and thus can adjust the interaction area with the core 15.

[0041] In the embodiments in which the Halbach array is used as described above with reference to FIGS. 4a-4b, the magnet 20 as shown in FIGS. 5a-5c is positioned such that magnetic field lines may substantially face the rotation shaft of the wheel 10 at the magnet 220. Accordingly, the interaction area between the magnet 20 and the core 15 is primarily determined by the side area of the magnet 220. For example, the side face of the magnet 220 may be substantially rectangular shaped, such that the interaction area can be changed during rotation.

[0042] When the magnet 200 is in the position as shown in FIG. 5b, the magnet 220 and a tooth 155 have the maximum interaction area. As the magnet 220 rotates, the interaction area between the magnet 220 and the tooth 155 is gradually decreased. In the state as shown in FIG. 5c, the interaction area between the magnet 220 and the tooth is decreased to the minimum. FIGS. 5d and 5e clearly show the change of the interaction area, in which the interaction area is mainly dependent on the overlapping area between
the tooth 155 and the magnet 220.

[0043] Due to the magnetic force present between the magnet 20 and the core 15, a detent force is provided for the rotation of the wheel 10. As described above, the rotation of the adjustment wheel 30 may rotate the magnet 20 via the first gear 35 and the second gear 40. When the magnet 20 rotates from the state in FIG. 5b by 90 degrees in the paper plane, it is switched to the state as shown in FIG. 5c. At this time, as the interaction area decreases, the magnetic force is reduced and so does the detent force.

[0044] The wheel assembly 100 according to embodiments of the subject matter described herein is applicable to various devices. For example, the wheel assembly 100 may be integrated into an input device such as a mouse, a trackball, or the like. Such input device at least provides two modes, namely a hyper mode and a resistance mode. In the hyper mode, the wheel substantially experiences no magnetic force, and thus the user can quickly and freely rotate the wheel. In the resistance mode, the user may perform a typical or fine operation on the wheel. Optionally, in the resistance mode, the resistance may be adjusted to adapt itself to the user's preference, thereby improving the user experience.

[0045] FIG. 6 illustrates a flowchart of an example method 600 of producing a wheel assembly 100 according to an embodiment of the subject matter described herein. It should be understood that the method 600 may also include additional acts not shown and/or may omit some acts as shown.

[0046] As shown in FIG. 6, at 620, a magnet 20 is arranged on a rotation plane of a wheel 10, which includes a core 15 capable of magnetically interacting with the magnet 20. At 640, a lever 60 is coupled to the magnet 20 to allow the magnet 20 to rotate with the rotation of the lever 60 to adjust the distance between the magnet 20 and the wheel 10. It should be understood that all the features about the wheel assembly 100 and the input device, as described above with reference to FIGS. 1 and 5c, are also applicable to the corresponding producing method and thus omitted here.

[0047] Some example embodiments of the subject matter described herein are listed as below.

[0048] In some embodiments, there is provide a wheel assembly for use in an input device, comprising: a magnet; a wheel comprising a core that is capable of magnetically interacting with the magnet, the magnet being arranged on a rotation plane of the wheel; and a lever coupled to the magnet and operable to adjust a distance between the magnet and the wheel by rotating the magnet with a rotation of the lever.
In some embodiments, the magnet is a permanent magnet.

In some embodiments, the magnet is a Halbach array.

In some embodiments, the core is an iron core.

In some embodiments, the wheel assembly further comprises: a torsion spring coupled to the lever and operable to apply a torsional force to the lever so as to counteract a magnetic force between the magnet and the core; and a cam coupled to the magnet and operable to change a force applied by the cam to the magnet based on a state of the cam so as to counteract the force applied by the torsion spring to the lever.

In some embodiments, the wheel assembly further comprises: a motor operable to rotate by a predetermined angle in response to a user's input so as to change the state of the cam.

In some embodiments, the wheel assembly further comprises: adjustment means operable to adjust a magnetic force between the magnet and the wheel by rotating the magnet substantially perpendicularly to the rotation plane of the wheel.

In some embodiments, the adjustment means comprises: an adjustment wheel operable to rotate in response to a user's input; an engagement mechanism coupled to the adjustment wheel and the magnet and operable to adjust an angle of the magnet with respect to the wheel in response to the rotation of the adjustment wheel.

In some embodiments, the engagement mechanism comprises: a first gear coupled to the adjustment gear and operable to rotate coaxially with the adjustment wheel; and a second gear engaged with the first gear and fixed to the magnet and operable to adjust the angle of the magnet with respect to the wheel.

In some embodiments, the magnet is positioned to produce a magnetic field substantially facing a rotation shaft of the wheel.

In some embodiments, the magnetic field has a substantially rectangular shaped cross-section.

In some embodiments, the core is a disk coaxially with the wheel.

In some embodiments, the core comprises a plurality of teeth arranged periodically on the edge of the core.

In some embodiments, there is provided an input device comprising a wheel assembly comprising: a magnet; a wheel comprising a core that is capable of magnetically interacting with the magnet, the magnet being arranged on a rotation plane of the wheel; and a lever coupled to the magnet and operable to adjust a distance between the magnet and the wheel by rotating the magnet with a rotation of the lever.
In some embodiments, the magnet is a permanent magnet.

In some embodiments, the magnet is a Halbach array.

In some embodiments, the core is an iron core.

In some embodiments, the wheel assembly further comprises: a torsion spring coupled to the lever and operable to apply a torsional force to the lever so as to counteract a magnetic force between the magnet and the core; and a cam coupled to the magnet and operable to change a force applied by the cam to the magnet based on a state of the cam so as to counteract the force applied by the torsion spring to the lever.

In some embodiments, the wheel assembly further comprises: a motor operable to rotate by a predetermined angle in response to a user's input so as to change the state of the cam.

In some embodiments, the wheel assembly further comprises: adjustment means operable to adjust a magnetic force between the magnet and the wheel by rotating the magnet substantially perpendicularly to the rotation plane of the wheel.

In some embodiments, the adjustment means comprises: an adjustment wheel operable to rotate in response to a user's input; an engagement mechanism coupled to the adjustment wheel and the magnet and operable to adjust an angle of the magnet with respect to the wheel in response to the rotation of the adjustment wheel.

In some embodiments, the engagement mechanism comprises: a first gear coupled to the adjustment gear and operable to rotate coaxially with the adjustment wheel; and a second gear engaged with the first gear and fixed to the magnet and operable to adjust the angle of the magnet with respect to the wheel.

In some embodiments, the magnet is positioned to produce a magnetic field substantially facing a rotation shaft of the wheel.

In some embodiments, the magnetic field has a substantially rectangular shaped cross-section.

In some embodiments, the core is a disk coaxially with the wheel.

In some embodiments, the core comprises a plurality of teeth arranged periodically on the edge of the core.

In some embodiments, there is provided a method of producing a wheel assembly comprising: arranging a magnet on a rotation plane of a wheel, the wheel comprising a core that is capable of magnetically interacting with the magnet; and coupling a lever to the magnet such that the magnet is rotatable with a rotation of the lever to adjust a distance between the magnet and the wheel.
Embodiments of the subject matter described herein are described as above, and the foregoing description is illustrative rather than exhausted, and not limited to the embodiments of the subject matter described herein. Multiple modifications and alternations without departing from the scope and the spirit of the illustrated embodiments of the subject matter described herein are obvious to those skilled in the art. The terms used herein are only intended to explain as much as possible the principle, and practical application or improvements to the technique in the market, of each embodiment, or enable those skilled in the art to better understand each embodiment of the subject matter described herein.
CLAIMS

1. A wheel assembly for use in an input device, comprising:
   a magnet;
   a wheel comprising a core that is capable of magnetically interacting with the magnet, the magnet being arranged on a rotation plane of the wheel; and
   a lever coupled to the magnet and operable to adjust a distance between the magnet and the wheel by rotating the magnet with a rotation of the lever.

2. The wheel assembly according to claim 1, wherein the magnet is a permanent magnet.

3. The wheel assembly according to claim 2, wherein the magnet is a Halbach array.

4. The wheel assembly according to claim 1, wherein the core is an iron core.

5. The wheel assembly according to claim 1, further comprising:
   a torsion spring coupled to the lever and operable to apply a torsional force to the lever so as to counteract a magnetic force between the magnet and the core; and
   a cam coupled to the magnet and operable to change a force applied by the cam to the magnet based on a state of the cam so as to counteract the force applied by the torsion spring to the lever.

6. The wheel assembly according to claim 5, further comprising:
   a motor operable to rotate by a predetermined angle in response to a user's input so as to change the state of the cam.

7. The wheel assembly according to claim 1, further comprising:
   adjustment means operable to adjust a magnetic force between the magnet and the wheel by rotating the magnet substantially perpendicularly to the rotation plane of the wheel.

8. The wheel assembly according to claim 7, wherein the adjustment means comprises:
   an adjustment wheel operable to rotate in response to a user's input;
   an engagement mechanism coupled to the adjustment wheel and the magnet and operable to adjust an angle of the magnet with respect to the wheel in response to the rotation of the adjustment wheel.

9. The wheel assembly according to claim 8, wherein the engagement mechanism comprises:
   a first gear coupled to the adjustment gear and operable to rotate coaxially with the
adjustment wheel; and

a second gear engaged with the first gear and fixed to the magnet and operable to adjust the angle of the magnet with respect to the wheel.

10. The wheel assembly according to claim 1, wherein the magnet is positioned to produce a magnetic field substantially facing a rotation shaft of the wheel.

11. The wheel assembly according to claim 10, wherein the magnetic field has a substantially rectangular shaped cross-section.

12. The wheel assembly according to claim 5, wherein the core is a disk coaxially with the wheel.

13. The wheel assembly according to claim 12, wherein the core comprises a plurality of teeth arranged periodically on the edge of the core.

14. An input device, comprising:

a wheel assembly according to any of claims 1-13.

15. A method of producing a wheel assembly, comprising:

arranging a magnet on a rotation plane of a wheel, the wheel comprising a core that is capable of magnetically interacting with the magnet; and

coupling a lever to the magnet such that the magnet is rotatable with a rotation of the lever to adjust a distance between the magnet and the wheel.
ARRANGE A MAGNET ON A ROTATION PLANE OF A WHEEL

COUPLE A LEVER TO THE MAGNET SUCH THAT THE MAGNET IS ROTATABLE ALONG WITH A ROTATION OF THE LEVER TO ADJUST A DISTANCE BETWEEN THE MAGNET AND THE WHEEL

FIG. 6
INTERNATIONAL SEARCH REPORT

PCT/US2017/063174

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06F3/0362 G06F3/01

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>A</td>
<td>paragraphs [0004] - [0005], [0012] - [0069]; claims 1-26; figures 1-19</td>
<td>7-9</td>
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<td>X,P</td>
<td>WO 2017/155762 A1 (MICROSOFT TECHNOLOGY LICENSING LLC [US]) 14 September 2017 (2017-09-14) paragraphs [0001] - [0064]; claims 1-15; figures 1-8</td>
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<td>EP 0 520 089 A1 (TANDBERG DATA [NO]) 30 December 1992 (1992-12-30) the whole document</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search

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<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 2007188453 A1</td>
<td>16-08-2007</td>
<td>CN 101021760 A</td>
<td>22-08-2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 102007007106 A1</td>
<td>04-10-2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2007188453 A1</td>
<td>16-08-2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2017155762 A1</td>
<td>14-09-2017</td>
</tr>
<tr>
<td>JP 2011145724 A</td>
<td>28-07-2011</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP H05181600 A</td>
<td>23-07-1993</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5696537 A</td>
<td>09-12-1997</td>
</tr>
</tbody>
</table>