



(11)

EP 4 818 846 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.10.2026 Bulletin 2026/41

(51) International Patent Classification (IPC):
G05G 1/10 ^(2006.01)

(21) Application number: **24896633.5**

(52) Cooperative Patent Classification (CPC):
G05G 1/10

(22) Date of filing: **28.11.2024**

(86) International application number:
PCT/CN2024/135163

(87) International publication number:
WO 2025/113547 (05.06.2025 Gazette 2025/23)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **GONG, Qiwei**
Shanghai 201306 (CN)
• **ZHANG, Junwei**
Shanghai 201306 (CN)
• **SUN, Huiqing**
Shanghai 201306 (CN)

(30) Priority: **30.11.2023 CN 202311627605**
30.11.2023 CN 202311627581

(74) Representative: **De Bortoli, Eros et al**
Zanoli & Giavarini S.p.A.
Via Melchiorre Gioia, 64
20125 Milano (IT)

(71) Applicant: **Yanfeng International Automotive
Technology Co., Ltd.**
Shanghai 201306 (CN)

(54) **KNOB ASSEMBLY AND CONTROL METHOD THEREFOR, VEHICLE-MOUNTED APPARATUS
OR ELECTRONIC DEVICE, AND VEHICLE**

(57) The present invention provides a knob assembly comprising: a knob, a torque output unit, a detection unit and a control unit. The detection unit is electrically connected with the control unit, and the control unit controls the torque output unit to provide a torque for the knob. The detection unit detects a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and transmits the characterization data to the control unit; the control unit determines a rotation rate or velocity of the knob based on the characterization data, and during the single rotation operation, dynamically adjusts the torque output unit based on the rotation rate or velocity to generate at least two torques for the knob in the single rotation operation. By simulating the number of the detents and force feedback of the mechanical knob, achieving dynamic force feedback by providing adjustable torque according to the rate or velocity at which the user adjusts the knob or by providing an adjustable torque combination according to the user's adjustment of the knob, thereby improving the user's experience (for example, the experience in the aspects of comfort, individuation and the like).

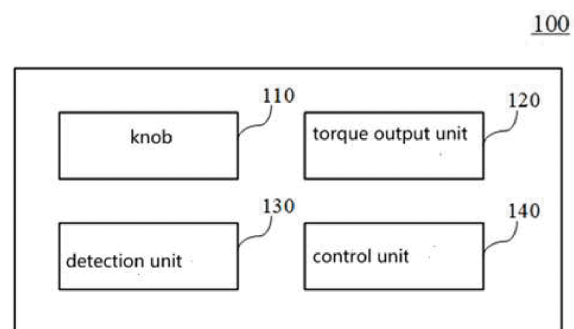


FIG. 1

EP 4 818 846 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to the field of switches, and specifically, relates to knob assemblies, control methods for the knob assemblies, in-vehicle apparatuses or electronic devices or appliances, and vehicles.

BACKGROUND ART

[0002] A knob switch is a switch assembly capable of adjusting a function object via rotation. Various rotary switches are widely applied in numerous fields, such as household electrical apparatuses or appliances, electronic devices, communication device, vehicles (e.g., motor vehicles and non-motor vehicles) or means of other transportation, by virtue of their features of multiple detents and convenient operation.

[0003] Conventional mechanical knobs have a fixed number of detents and typically support adjustment of only a single function, or multiple functions are adjusted with the same number of detents. In addition, such mechanical knobs usually provide a single force feedback, making it difficult to offer different hand feelings for the same or different users, and thus failing to meet personalized usage requirements of customers or consumers.

CONTENT OF THE INVENTION

[0004] In view of the above-described drawbacks in the prior art, the present invention provides a knob assembly, a control method for the knob assembly, an in-vehicle apparatus or electronic device or appliance, and a vehicle. By simulating the number of detents and force feedback of the mechanical knob, the present invention achieves dynamic force feedback by providing adjustable torque according to the rate or velocity at which the user adjusts the knob or by providing an adjustable torque combination according to the user's adjustment of the knob, thereby improving the user's experience (for example, the experience in the aspects of comfort, individuation and the like).

[0005] According to a first aspect of the present invention, there is provided a knob assembly, including: a knob, a torque output unit, a detection unit and a control unit, the detection unit being electrically connected with the control unit, and the control unit controlling the torque output unit to provide a torque for the knob, wherein the detection unit detects a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and transmits the characterization data to the control unit; the control unit determines a rotation rate or velocity of the knob based on the characterization data, and the control unit, during the single rotation operation, dynamically adjusts the torque output

unit based on the rotation rate or velocity to generate at least two torques for the knob in the single rotation operation.

[0006] According to a second aspect of the present invention, a control method for a knob assembly is provided. The knob assembly includes a knob, a torque output unit, a detection unit and a control unit; the detection unit is electrically connected with the control unit, and the control unit controls the torque output unit to provide a torque for the knob. The method includes the steps of: detecting a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob and transmitting the characterization data to the control unit by the detection unit; determining a rotation rate or velocity of the knob based on the characterization data by the control unit; and during the single rotation operation, dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to provide an adjustable torque for the knob in the single rotation operation.

[0007] The knob assembly according to the aforementioned first aspect or the control method for a knob assembly according to the second aspect may include any of the following preferred features, alone or in combination.

[0008] In some embodiments, dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques or an adjustable torque for the knob in the single rotation operation includes: determining a plurality of detents traversed during the single rotation operation based on the rotation rate or velocity, wherein the plurality of detents includes at least a first detent segment and a second detent segment subsequent to the first detent segment; and during the first detent segment: generating first control information for the first detent segment based on a first reference torque; and outputting a control signal to the torque output unit according to the first control information; and during the second detent segment: if the obtained rotation rate or velocity is higher than a rate or velocity threshold range or a rate or velocity threshold value, generating second control information for the second detent segment based on a second reference torque different from the first reference torque; and outputting a control signal to the torque output unit according to the second control information.

[0009] In some embodiments, the plurality of detents further includes a third detent segment between the first detent segment and the second detent segment; and dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques or an adjustable torque for the knob in the single rotation operation includes: during the third detent segment: generating third control information for the third detent segment based on a third reference torque between the first reference torque and the second reference torque; and outputting a control signal to the

torque output unit according to the third control information.

[0010] In some embodiments, the control unit further performs: during the second detent segment, if the obtained rotation rate or velocity is within the rate or velocity threshold range, or lower than the rate or velocity threshold range or the rate or velocity threshold value, then maintaining use of the first control information to control the torque output unit to provide a torque for the knob.

[0011] In some embodiments, the plurality of detents further includes a fourth detent segment subsequent to the second detent segment; and dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques or an adjustable torque for the knob in the single rotation operation includes: during the fourth detent segment: if the obtained rotation rate or velocity is lower than the rate or velocity threshold range or the rate or velocity threshold value, generating fourth control information for the fourth detent segment based on the first reference torque; and outputting a control signal to the torque output unit according to the fourth control information.

[0012] In some embodiments, a relative gradient relationship between the first reference torque and the second reference torque is based on a rotational direction.

[0013] In some embodiments, the control unit further acquires function object information corresponding to the single rotation adjustment operation; and at least one of the first reference torque, the second reference torque, and a relative gradient relationship between the first reference torque and the second reference torque is based on rotational direction data and/or the function object information.

[0014] In some embodiments, generating control information for the detent based on the reference torque includes: acquiring a torque profile for the detents based on the reference torque, wherein the torque profile includes at least a positive output torque stage and a negative output torque stage; and generating control information for the detents based on the torque profile.

[0015] In some embodiments, the reference torque is a peak torque for the detent.

[0016] In some embodiments, the control unit further performs: detecting whether the single rotation operation is completed based on the characterization data; after completion of the single rotation operation, controlling the torque output unit to provide zero torque or another preset torque for the knob.

[0017] In some embodiments, the control unit further performs: determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation; determining an ending detent of the single rotation operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.

[0018] In some embodiments, determining the initial detent of the single rotation operation includes: if the

single rotation operation of the knob is the first operation, determining the initial detent as a preset detent, or if the single rotation operation of the knob is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.

[0019] In some embodiments, the control unit further performs: if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent; generating control information for the limit detent based on the limit torque; and outputting a control signal to the torque output unit according to the control information for the limit detent.

[0020] In some embodiments, the function object information is associated with a function object selected from a plurality of adjustable parameters, wherein the plurality of adjustable parameters is associated with the same component, or at least two of the adjustable parameters are associated with different components.

[0021] In some embodiments, a rotational axis of the knob rotates together with the torque output unit; and a rotational axis of the knob is aligned with a rotational axis of the torque output unit, or a rotational axis of the knob is not aligned with a rotational axis of the torque output unit, and the knob and the torque output unit are connected by means of a transmission.

[0022] According to an aspect of the present invention, there is provided a knob assembly, including: a knob, a torque output unit, a detection unit and a control unit; the detection unit is electrically connected with the control unit, and the control unit is capable of controlling the torque output unit to provide a torque for the knob; wherein the detection unit is configured to detect a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and to transmit the characterization data to the control unit; the control unit is configured to determine a rotation rate or velocity of the knob based on the characterization data, and the control unit is further configured to, during the single rotation operation, dynamically adjust the torque output unit based on the rotation rate or velocity to generate at least two different torques for the knob or to provide an adjustable torque for the knob in the single rotation operation.

[0023] According to an aspect of the present invention, there is provided a knob assembly, including: a knob, a torque output unit, a detection unit and a control unit; the detection unit is electrically connected with the control unit, and the control unit controls the torque output unit to provide a torque for the knob; wherein the detection unit detects a rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and transmits the characterization data to the control unit; the control unit is provided with at least one torque combination, and the control unit identifies a single rotation operation based on the characterization data,

and configures the torque combination for the single rotation operation.

[0024] In some embodiments, the control unit further determines whether the single rotation operation is completed based on the characterization data, and after completion of the single rotation operation, resets the torque configuration as the torque combination or configures the torque as an initial torque.

[0025] In some embodiments, a first duration threshold is set, and the control unit resets a torque combination configuration or configures the torque as an initial torque after the first duration threshold has elapsed subsequent to completion of the single rotation operation.

[0026] In some embodiments, the control unit further acquires or stores function object information corresponding to the knob; and configuring the torque combination for the single rotation operation by the control unit includes: configuring the torque combination for the single rotation operation based on the function object information by the control unit.

[0027] In some embodiments, the function object information is associated with function objects, which have the same or different torque combinations for different rotational directions.

[0028] In some embodiments, the control unit identifies one or more detents traversed during the single rotation operation based on the characterization data; and configuring the torque combination for the single rotation operation by the control unit includes: for each of the one or more detents: determining a reference torque for each detent; generating control information for each detent based on the determined reference torque for each detent; controlling the torque output unit to provide a torque for the knob according to the control information for each detent.

[0029] In some embodiments, the control unit identifies that the rotational position, the displacement, the angle or the radian generated by the single rotation operation exceeds a detent coverage of the torque combination, and the control unit configures a first preset torque for portions of the single rotation operation where the rotational position, the displacement, the angle or the radian exceeds the detent coverage of the torque combination.

[0030] In some embodiments, the first preset torque is consistent with an end torque of the torque combination, or a hand feeling provided by the first preset torque is consistent with that provided by the end torque of the torque combination.

[0031] In some embodiments, determining a reference torque for each detent includes: based on a detent-torque mapping relationship, determining a reference torque for each detent.

[0032] In some embodiments, the detents are classified in terms of levels, and the detent-torque mapping relationship is determined according to a level-torque mapping relationship, and the number of the levels is less than or equal to the number of the detents.

[0033] In some embodiments, the control unit further

performs: acquiring a correspondence table of the function object and the detent-torque mapping relationship, and determining the detent-torque mapping relationship based on the function objects corresponding to the function object information.

[0034] In some embodiments, generating control information for each detent based on the determined reference torque for each detent includes: acquiring a torque profile for each detent based on the determined reference torque for each detent, wherein the torque profile includes at least a positive output torque stage and a negative output torque stage; generating control information for each detent based on the torque profile.

[0035] In some embodiments, the reference torque is a peak torque for each detent.

[0036] In some embodiments, the control unit further performs: determining whether the single rotation operation is completed based on the characterization data; and after completion of the single rotation operation, controlling the torque output unit to provide zero torque or an initial torque or a second preset torque for the knob, wherein the second preset torque has a limiting and fixing effect on the knob, and the initial torque is an initial segment torque of the torque combination.

[0037] In some embodiments, the control unit further performs: determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation; determining an ending detent of the single rotation adjustment operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.

[0038] In some embodiments, determining the initial detent of the single rotation adjustment operation includes: if the single rotation operation of the knob is the first operation, determining the initial detent as a third preset detent, or if the single rotation operation of the knob is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.

[0039] In some embodiments, the control unit further performs: if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent; generating control information for the limit detent based on the limit torque; and controlling the torque output unit to provide a torque for the knob according to the control information for the limit detent.

[0040] In some embodiments, a function object corresponding to the function object information is selected from a plurality of adjustable parameters, wherein the plurality of adjustable parameters is associated with the same component, or at least two of the adjustable parameters are associated with different components.

[0041] In some embodiments, the knob is capable of rotating together with the torque output unit; and a rotational axis of the knob is aligned with a rotational axis of the torque output unit, or a rotational axis of the knob is not aligned with a rotational axis of the torque output unit,

and the knob and the torque output unit are connected by means of a transmission.

[0042] In some embodiments, the torque combination includes at least two different torques.

[0043] According to an aspect of the present invention, there is provided a control method for a knob assembly. The knob assembly includes a knob, a torque output unit, a detection unit, and a control unit, wherein the detection unit is electrically connected with the control unit, and the control unit controls the torque output unit to provide a torque for the knob. The method includes the steps of: detecting a rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian of the knob and transmitting the characterization data to the control unit by the detection unit, providing the control unit with a torque combination, and determining a beginning end and a finishing end of a single rotation operation based on the characterization data and configuring the torque combination based on the beginning end and/or the finishing end by the control unit.

[0044] In some embodiments, the control unit resets the torque configuration as the torque combination or configures the torque as an initial torque prior to the beginning end or subsequent to the finishing end.

[0045] In some embodiments, a first duration threshold is set, and the control unit identifies the finishing end, and resets the torque configuration as the torque combination or configures the torque as the initial torque after the first duration threshold has elapsed subsequent to a time point corresponding to the finishing end.

[0046] In some embodiments, the control unit further acquires or stores function object information corresponding to the knob; and configuring the torque combination by the control unit includes: configuring the torque combination for the single rotation operation based on the function object information by the control unit.

[0047] In some embodiments, the function object information is associated with function objects, which have the same or different torque combinations for different rotational directions.

[0048] In some embodiments, the control unit identifies one or more detents traversed during the single rotation operation based on the characterization data; and the control unit configuring the torque combination for each of the single rotation operations includes: for each of the one or more detents: determining a reference torque for each detent; generating control information for each detent based on the determined reference torque for each detent; controlling the torque output unit to provide a torque for the knob according to the control information for each detent.

[0049] In some embodiments, the control unit identifies that the rotational position, the displacement, the angle or the radian generated by the single rotation operation exceeds a detent coverage of the torque combination, and the control unit configures a first preset torque for portions of the single rotation operation where the rota-

tional position, the displacement, the angle or the radian exceeds the detent coverage of the torque combination.

[0050] In some embodiments, the first preset torque is consistent with an end torque of the torque combination, or a hand feeling provided by the first preset torque is consistent with that provided by the end torque of the torque combination.

[0051] In some embodiments, determining a reference torque for each detent includes: based on a detent-torque mapping relationship, determining a reference torque for each detent.

[0052] In some embodiments, the detents are classified in terms of levels, and the detent-torque mapping relationship is determined according to a level-torque mapping relationship, and the number of the levels is less than or equal to the number of the detents.

[0053] In some embodiments, the control unit further performs: acquiring a correspondence table of function objects and the detent-torque mapping relationship, and determining the detent-torque mapping relationship based on the function objects corresponding to the function object information.

[0054] In some embodiments, generating control information for each detent based on the determined reference torque for each detent includes: acquiring a torque profile for each detent based on the determined reference torque for each detent, wherein the torque profile includes at least a positive output torque stage and a negative output torque stage; generating control information for each detent based on the torque profile.

[0055] In some embodiments, the reference torque is a peak torque for each detent.

[0056] In some embodiments, the control unit further performs: determining whether the single rotation operation is completed based on the characterization data; and after completion of the single rotation operation, controlling the torque output unit to provide zero torque or an initial torque or a second preset torque for the knob, wherein the second preset torque has a limiting and fixing effect on the knob, and the initial torque is an initial segment torque of the torque combination.

[0057] In some embodiments, the control unit further performs: determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation; determining an ending detent of the single rotation adjustment operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.

[0058] In some embodiments, determining the initial detent of the single rotation adjustment operation includes: if the single rotation operation of the knob is the first operation, determining the initial detent as a third preset detent, or if the single rotation operation of the knob is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.

[0059] In some embodiments, the control unit further

performs: if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent; generating control information for the limit detent based on the limit torque; and controlling the torque output unit to provide a torque for the knob according to the control information for the limit detent.

[0060] In some embodiments, a function object corresponding to the function object information is selected from a plurality of adjustable parameters, wherein the plurality of adjustable parameters is associated with the same component, or at least two of the adjustable parameters are associated with different components.

[0061] In some embodiments, the torque combination includes at least two different torques.

[0062] According to a third aspect of the present invention, there is provided an in-vehicle apparatus or electronic device or appliance including the knob assembly according to the aforementioned first aspect.

[0063] According to a fourth aspect of the present invention, a computer-readable storage medium is provided, including computer instructions stored thereon, wherein the computer instructions, when executed by a processor, cause the processor to execute the control method for a knob assembly according to the aforementioned second aspect.

[0064] According to a fourth aspect of the present invention, there is provided a vehicle including the knob assembly described in the first aspect or the in-vehicle apparatus or electronic device or appliance described in the third aspect.

[0065] Compared with the conventional mechanical knob, the present invention has the beneficial effects of providing a dynamic control over the tactile feedback of the knob by performing dynamic feedback for the rotation rate of the adjustment knob, thereby capable of meeting the personalized use requirements of customers or consumers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0066] Other features and advantages of the present invention will be better understood from the following preferred embodiments to be described in detail in conjunction with the accompanying drawings, wherein like reference signs denote like or similar components.

FIG. 1 is a block diagram of an exemplary knob assembly according to a first and a second embodiment of the present invention.

FIG. 2 illustrates exemplary multiple rotation operation processes according to the first and second embodiments of the present invention.

FIG. 3 illustrates an exemplary single rotation operation according to the first and second embodiments of the present invention.

FIG. 4 illustrates a control method for a knob assembly according to the first embodiment of the present invention.

FIG. 5 illustrates an exemplary torque control process according to the first embodiment of the present invention.

FIG. 6 illustrates another exemplary torque control process according to the first embodiment of the present invention.

FIG. 7 illustrates a torque profile according to the first embodiment of the present invention.

FIG. 8 illustrates an exemplary reference torque-rate or velocity curve according to the first embodiment of the present invention.

FIG. 9 illustrates an exemplary limit torque according to the first embodiment of the present invention.

FIG. 10 illustrates a control method for a knob assembly according to the second embodiment of the present invention.

FIG. 11 illustrates another control method for a knob assembly according to the second embodiment of the present invention.

FIG. 12 illustrates an exemplary torque control process according to the second embodiment of the present invention.

FIG. 13 illustrates another exemplary torque control process according to the second embodiment of the present invention.

FIG. 14 illustrates a torque profile according to the second embodiment of the present invention.

FIG. 15 illustrates an exemplary reference torque-detent mapping curve according to the second embodiment of the present invention.

FIG. 16 illustrates an exemplary reference torque-level mapping profile according to the second embodiment of the invention.

FIG. 17 illustrates an exemplary limit torque according to the second embodiment of the present invention.

FIG. 18 illustrates the structure of an exemplary knob assembly according to the first and second embodiments of the present invention.

FIG. 19 illustrates components of the knob assembly of FIG. 18 according to the first and second embodiments of the present invention.

FIG. 20 illustrates an exemplary in-vehicle apparatus, electronic device or appliance including the knob assembly according to the first and second embodiments of the present invention.

EMBODIMENTS

[0067] As described below, a knob assembly, a control method for the knob assembly, an in-vehicle apparatus or an electronic device or an appliance, a computer-readable storage medium and a vehicle are provided in some exemplary embodiments of the present disclosure. More specifically, the present disclosure is intended to solve the aforementioned problems.

[0068] With reference to FIG. 1, a block diagram of an exemplary knob assembly 100 according to a first and a

second embodiment of the present invention is illustrated. The knob assembly 100 includes a knob 110, a torque output unit 120, a detection unit 130, and a control unit 140. The knob 110 may be rotatable in one direction (e.g., clockwise or counter-clockwise) or in two directions, which is not limited herein. The detection unit 130 may detect a rotation operation of the knob 110 so as to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob 110. For example, the detection unit 130 may directly detect the rotation operation of the knob 110, or may indirectly detect the rotation operation of the knob 110 by detecting a rotation operation of the torque output unit 120 that can rotate together with the knob 110. For example, the detection unit 130 may be an encoder, a sensor (e.g., an infrared sensor or a photo-electric sensor), or other detection components (e.g., a camera, etc.) known in the art that can be used to detect a rotational state, and outputs characterization data regarding the rotational state (e.g., a rotational position, a displacement, an angle or a radian, etc.). The detection unit 130 is electrically connected with the control unit 140 to transmit the characterization data to the control unit 140. The control unit 140 may control the torque output unit 120 to dynamically provide torque for the knob 110 based on the characterization data.

[0069] FIG. 2 illustrates exemplary multiple rotation operation processes according to an embodiment of the present invention. As shown in FIG. 2, the knob 110 is operated to: rotate clockwise during a time period from t_0 to t_1 ; stop rotation during a time period from t_1 to t_2 ; rotate clockwise during a time period from t_2 to t_3 ; stop rotation during a time period from t_3 to t_4 ; and rotate counter-clockwise during a time period from t_4 to t_5 . For example, when the rotation stop duration is less than a duration threshold (or referred to as a stop-duration threshold), adjacent rotation processes may be regarded as belonging to a single rotation operation; when the rotation stop duration is greater than the duration threshold (or referred to as the stop-duration threshold), adjacent rotation processes may be regarded as belonging to different rotation operations.

[0070] FIG. 3 illustrates an exemplary single rotation operation according to the first and second embodiments of the present invention. As shown in FIG. 3, a single rotation of the knob may be represented as a process of change from an initial (end) rotational position, displacement, angle, radian or the like to a terminal (end) (or final-end) rotational position, displacement, angle, radian or the like (e.g., the illustrated angle θ). The detection unit 130 can obtain characterization data by detecting a rotational position, a displacement, an angle, a radian, or the like at different times. For example, preferred variations in the rotational position, displacement, angle, radian or the like may be set based on the rotation plane of the knob and the human-machine interaction distance. Taking angle as an example, the angle θ may preferably be set within a range of $[30^\circ, 120^\circ]$. For instance, when a

single rotation operation exceeds 120° , the rotation operation shall be deemed to rotate by 120° rather than by an angle exceeding 120° , so as to avoid misoperation or excessive rotation in a single rotation. Alternatively, the torque at 120° may be maintained while the control recognition remains consistent with the actual rotation operation. Similarly, a selected range may be set for preferred variations in the rotational position, displacement, or radian.

[0071] A process of providing adjustable torque based on a rate or velocity to achieve dynamic force feedback according to the first embodiment of the present invention will be described in detail with reference to FIGS. 4-9.

[0072] FIG. 4 shows a control method 200 for a knob assembly according to the first embodiment of the present invention. The method 200 may be executed by any one of the knob assembly 100 of FIG. 1, a knob assembly 300 of FIG. 18, or a knob assembly 410 of an in-vehicle apparatus or electronic device or appliance 400 of FIG. 20. As shown, the method 200 includes steps 210 to 230.

[0073] In step 210, the detection unit detects a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and transmits the characterization data to the control unit.

[0074] In step 220, the control unit determines a rotation rate or velocity of the knob based on the characterization data. For example, the control unit can determine the rotation rate or velocity of the knob according to the characterization data received from the detection unit at different times. For example, the control unit can determine a rotational angular velocity according to a change in the rotation angle with respect to time. For example, the control unit can determine a rotational linear velocity according to a change in the rotational position with respect to time, and determine the rotational angular velocity according to a rotational radius of the knob.

[0075] In some examples, the knob 110 can rotate together with the torque output unit 120, and the rate or velocity of the knob can be determined based on the relative relationship between the rotation rates or velocities of the knob 110 and the torque output unit 120. For example, when the rotational axes of the knob 110 and the torque output unit 120 are aligned, both the knob 110 and the torque output unit 120 have the same rotation rate or velocity, whereas when the rotational axes of the knob 110 and the torque output unit 120 are not aligned, the knob 110 and the torque output unit 120 are connected by means of a transmission, and may have the same or different rate or velocity ratio. The rotation rate or velocity of the knob 110 can be determined by determining the rotation rate or velocity of the torque output unit 120 based on the ratio.

[0076] In step 230, the control unit, during a single rotation operation, dynamically adjusts the torque output unit 120 based on the rotation rate or velocity to generate at least two (e.g., different) torques for the knob 110 or dynamically adjusts the torque output unit 120 to provide

an adjustable torque for the knob 110 in the single rotation operation.

[0077] In some examples, step 230 may include: determining a plurality of detents traversed during the single rotation operation based on the characterization data or the rotation rate or velocity, wherein the plurality of detents includes at least a first detent segment and a second detent segment subsequent to the first detent segment; and during the first detent segment: generating first control information for the first detent segment based on a first reference torque, and outputting a control signal to the torque output unit according to the first control information; and during the second detent segment: if the obtained rotation rate or velocity is higher than a rate or velocity threshold range or a rate or velocity threshold value, generating second control information for the second detent segment based on a second reference torque different from the first reference torque, and outputting a control signal to the torque output unit according to the second control information. Here, the reference torques can, for example, each correspond to, for example, be equal to, the at least two torques generated as described above.

[0078] Taking angle as an example, assuming that the total number of the detents of the knob (for a 360 ° rotation) is 30, the number of the detents traversed during a single rotation operation can be determined based on the angular velocity, the linear velocity, the change in angle, and the change in position. For example, when a single rotation of 60 ° is performed, it can be determined that 5 detents have been traversed.

[0079] Turning to FIGS. 5 and 6, FIG. 5 shows an exemplary torque control process according to the first embodiment of the present invention, and FIG. 6 shows another exemplary torque control process according to the first embodiment of the present invention. As shown in FIG. 5 and 6, the torque variation of the knob may include at least a first stage and a second stage. In the first stage associated with the first detent segment (e.g., one or more detents), at which time the rotation adjustment starts, the calculation of the rotation rate or velocity has not yet been completed, and the torque feedback of the knob may be set to a default value, such as a first reference torque. Correspondingly, the control unit may generate first control information for the first detent segment based on the first reference torque, and output a control signal to the torque output unit according to the first control information to provide a corresponding torque. In the second stage associated with the second detent segment (e.g., one or more detents), after the rotation rate or velocity has been calculated, if the rate or velocity V1 or V2 exceeds the rate or velocity threshold range or the rate or velocity threshold value, the torque of the knob enters an adjustment stage, and the torque feedback of the knob may be set to a second reference torque different from the first reference torque. Correspondingly, the control unit may generate second control information for the second detent segment based on the

second reference torque, and output a control signal to the torque output unit according to the second control information to provide a corresponding torque. Here, the "rate or velocity threshold range" may be a predetermined threshold range or threshold interval of rate or velocity, and the "rate or velocity threshold value" may be a predetermined threshold point value of rate or velocity.

[0080] For example, the second reference torque may be lower than the first reference torque (decreasing shown in FIG. 5) or higher than the first reference torque (increasing shown in FIG. 6). In some examples, a relative gradient relationship between the first reference torque and the second reference torque (e.g., increasing or decreasing) is based on a rotational direction, e.g., different torque force feedbacks are provided in different rotational directions.

[0081] In some examples, the control unit 140 further acquires function object information corresponding to a single rotation adjustment operation (e.g., information indicating function objects, which may be, for example, various adjustable parameters such as FM selection, volume of sound, etc.), wherein at least one of the first reference torque, the second reference torque, and the relative gradient relationship between the first reference torque and the second reference torque is based on rotational direction data and/or the function object information. For example, for different rotational directions and/or function objects, there may be the same or different reference torque starting values or adjustment values or there may be different torque variation trends, thereby providing different torque force feedbacks.

[0082] For example, decreasing the torque feedback upon rapid adjustment of the knob 110 and increasing the torque feedback in opposite case can satisfy the demand for rapid adjustment and fine tuning, such as FM selection. For example, increasing the torque feedback upon fast adjustment and decreasing the torque feedback in opposite case can avoid the effect of too fast function adjustment, such as a sudden increase in volume.

[0083] For example, the function object information is associated with function objects, and the function objects are selected from a plurality of adjustable parameters. The plurality of adjustable parameters may be associated with the same component, or at least two of the adjustable parameters may be associated with different components. For example, the knob 110 may be used to adjust multiple function objects of the same component, or to adjust multiple different function objects of multiple different components. For example, the function object information may be obtained by acquiring a user's selection of the function object (via user input such as touch screen input, voice input, key input, or the like).

[0084] Optionally, as shown in FIGS. 5 and 6, the torque variation of the knob 110 may include a third stage (i.e., a transition stage) between the first stage and the second stage, corresponding to a third detent segment (one or more detents). The torque feedback of the knob 110 may be set to a third reference torque between the

first reference torque and the second reference torque. Correspondingly, the control unit 140 can generate third control information for the third detent segment based on the third reference torque, and output a control signal to the torque output unit based on the third control information to provide a corresponding torque. By providing the transition stage, discomfort to the user from sudden changes in torque can be avoided.

[0085] In some examples, during the second stage, if the obtained rotation rate or velocity is within the rate or velocity threshold range, or lower than the rate or velocity threshold range or the rate or velocity threshold value, the first control information is kept in use to control the torque output unit 120 to provide the torque for the knob 110, and whether to adjust the torque variation continues to be judged in the subsequent stage.

[0086] After the torque adjustment has been completed, the variation in the torque may continue to be controlled through the rate or velocity of the knob 110. For example, the plurality of detents further includes a fourth detent segment (e.g., one or more detents) subsequent to the second detent segment. During the fourth detent segment: if the obtained rotation rate or velocity is lower than the rate or velocity threshold range or the rate or velocity threshold value, the torque feedback of the knob 110 may be set back to the default value, such as the first reference torque. Correspondingly, the control unit 140 generates fourth control information for the fourth detent segment based on the first reference torque, and outputs a control signal to the torque output unit based on the fourth control information to provide a corresponding torque.

[0087] Turning to FIG. 7, a torque profile according to the first embodiment of the present invention is shown. The aforesaid operation of generating control information for the detent based on the reference torque may include: acquiring a torque profile for the detents based on the reference torque, wherein the torque profile includes at least a positive output torque stage and a negative output torque stage; and generating control information for the detents based on the torque profile. By having the torque profile that includes the positive output torque stage and the negative output torque stage, a user manipulating the knob 110 can be provided with compliant feedback and resistive feedback, so as to easily perceive the change in the detent. For example, the reference torque may be a peak torque on the torque profile of FIG. 8 for the detent.

[0088] FIG. 8 illustrates an exemplary reference torque-rate or velocity curve according to the first embodiment of the present invention. As shown in FIG. 8, in some examples, the reference torque (e.g., the first reference torque, the second reference torque, or more) may vary as a function of the rate or velocity. For example, for different rate or velocity ranges, there may be different reference torques, so as to provide the user with a hand feeling at different rotation rates or velocities.

[0089] Turning back to FIG. 4, the method 200 may further include performing, by the control unit, the follow-

ing operations: detecting whether the single rotation operation is completed based on the characterization data; and, after completion of the single rotation operation, controlling the torque output unit to provide zero torque or another preset torque for the knob. For example, when the rotation is completed, the torque feedback may be released or a preset torque feedback may be provided for the user to remind the user of completion of the rotation. This step may be performed, for example, immediately after completion of the single rotation operation, or after a time period has elapsed subsequent to completion of the single rotation operation.

[0090] The method 200 may further include performing the following operations by the control unit: determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation, and determining an ending detent of the single rotation operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range. This step can prevent the rotation operation from exceeding the actual detent range of the function object.

[0091] For example, determining the initial detent of the single rotation operation may include: if the single rotation operation of the knob 110 is the first operation, determining the initial detent as a preset detent, or if the single rotation operation of the knob 110 is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.

[0092] The method 200 may further include performing the following operations by the control unit: if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent; generating control information for the limit detent based on the limit torque; and outputting a control signal to the torque output unit 120 according to the control information for the limit detent.

[0093] Turning to FIG. 9, an exemplary limit torque according to an embodiment of the present invention is shown. The knob 110 has a boundary stop or limit detent in at least one direction, and for the limit detent, limit torque feedback may be provided by a limit torque different from the reference torque used during torque adjustment. For example, a large limit torque feedback may be provided to limit further rotation by the user.

[0094] A process of providing adjustable torque based on a single rotation operation to achieve dynamic force feedback is described in detail below in conjunction with FIG. 10-17.

[0095] FIG. 10 shows a control method 200 for a knob assembly according to the second embodiment of the present invention. The method 200 may be executed by any one of the knob assembly 100 of FIG. 1, the knob assembly 300 of FIG. 18, or the knob assembly 410 of the in-vehicle apparatus or electronic device or appliance 400 of FIG. 20. As shown, the method 200 includes steps 210-220.

[0096] In step 210, the detection unit 130 detects a single rotation operation of the knob 110 to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob 110, and transmits the characterization data to the control unit 140.

[0097] In step 220, the control unit 130 is provided with at least one torque combination, and the control unit 130 determines the single rotation operation based on the characterization data and configures the torque combination for the single rotation operation. For example, the configured torque combination is one of the at least one torque combination. For example, the configured torque combination includes at least two different torques.

[0098] In some examples, the knob 110 may rotate together with the torque output unit 120. For example, when the rotational axes of the knob 110 and the torque output unit 120 are aligned, both the knob 110 and the torque output unit 120 have the same rotational state, whereas when the rotational axes of the knob 110 and the torque output unit 120 are not aligned, the knob 110 and the torque output unit 120 are connected by means of a transmission, and may have the same or different rotation ratio. The rotational state (e.g., characterization data) of the knob 110 can be determined by determining a rotational state of the torque output unit 120 based on the ratio.

[0099] In some examples, the control unit 140 may also determine whether the single rotation operation is completed based on the characterization data and may, after completion of the single rotation operation, reset the torque configuration as the torque combination or configure the torque as an initial torque. For example, the torque feedback of the knob 110 may be set as the torque combination or as the initial torque immediately after the completion of the single rotation operation to remind the user of the completion of the rotation.

[0100] In some examples, the control unit 140 may reset the torque combination configuration or configure the torque as the initial torque after a first duration threshold has elapsed subsequent to the completion of the single rotation operation. For example, the control unit 140 may, after a delay subsequent to the completion of the single rotation operation, set the torque feedback of the knob 110 as the torque combination or as the initial torque to remind the user of the completion of the rotation.

[0101] In some examples, the control unit 140 may also acquire or store corresponding function object information of the knob 110, and the step 220 may include configuring the torque combination for the single rotation operation based on the function object information. For example, different function object information may correspond to different torque combinations, such that different dynamic torque feedbacks may be provided for different function objects.

[0102] In some examples, the function object information is associated with function objects, which have the same or different torque combinations for different rota-

tional directions.

[0103] In some examples, the control unit 140 may also identify one or more detents traversed during the single rotation operation based on the characterization data, and the step 220 may include: for each of the one or more detents: determining a reference torque for each detent; generating control information for each detent based on the determined reference torque for each detent; and controlling the torque output unit to provide the torque for the knob based on the control information for each detent.

[0104] Taking angle as an example, assuming that the total number of the detents of the knob (for a 360° rotation) is 30, the number of the detents traversed during the single rotation operation can be determined based on the angular velocity, the linear velocity, the change in angle, and the change in position. For example, when a single rotation of 60° is performed, it can be determined that 5 detents have been traversed.

[0105] Turning to FIGS. 12 and 13, FIG. 12 shows an exemplary torque control process according to the second embodiment of the present invention, and FIG. 13 shows another exemplary torque control process according to the second embodiment of the present invention. As shown in FIGS. 12 and 13, the torque variation of the knob 110 may include a variation in the torque during the single rotation operation (e.g., a first rotation operation and a second rotation operation shown in the figures).

[0106] In the first rotation operation or the second rotation operation, as the number of the detents traversed increases, the reference torque for the detent may vary according to a predetermined trend (for example, increasing, decreasing, or varying in a predetermined other trends), thereby configuring a torque combination for the rotation operation. As previously mentioned, when the rotation interval is greater than the stop duration threshold, the first rotation operation and the second rotation operation are deemed to be different rotation operations. In this way, each rotation adjustment starts at a zero position of torque-and-rotation mapping, thereby achieving torque feedback with relative gradient variation.

[0107] Further, although in FIGS. 12 and 13, the same function object has different torque combinations for different rotational directions, in other examples, the same function object may have the same torque combination for different rotational directions.

[0108] Turning to FIG. 14, a torque profile according to an embodiment of the present invention is shown. The aforesaid operation of generating control information for the detent based on the reference torque may include: acquiring a torque profile for the detents based on the reference torque, wherein the torque profile includes at least a positive output torque stage and a negative output torque stage; and generating control information for the detents based on the torque profile. By having the torque profile that includes the positive output torque stage and the negative output torque stage, a user manipulating the knob can be provided with compliant feedback and re-

sistive feedback, so as to easily perceive the change in the detent. For example, the reference torque may be a peak torque on the torque profile of FIG. 15 for the detent.

[0109] FIG. 15 illustrates an exemplary reference torque-detent mapping curve according to an embodiment of the present invention. As shown in FIG. 15, in some examples, the reference torque may vary depending on the detent. For example, for different detent ranges, there may be different reference torques, so as to provide the user with hand feeling at different detents. For example, the initial torque in the initial segment and the end torque in the final segment of the torque combination may not be the same, or at least one of the initial torque and the end torque may not be the same as the torque in the intermediate segment (between the initial segment and the final segment).

[0110] In some examples, determining a reference torque for each detent may include: based on a detent-torque mapping relationship, determining a reference torque for each detent.

[0111] In some examples, the detents may be classified in terms of levels, and the detent-torque mapping relationship may be determined according to a level-torque mapping relationship, wherein the number of the levels is less than or equal to the number of the detents.

[0112] Refer to FIG. 16, which shows an exemplary reference torque-level mapping profile according to the second embodiment of the present invention. For example, the relative adjustable range of the torque may be divided into M levels with the number of the detents N as the base, where M may be less than N, which can, for example, avoid discomfort to the user due to excessively fine division of the detents. For example, it can be set that $M = k * N$, where $k \in (0, 1]$. Alternatively, other non-linear mapping or piecewise mapping may be employed. As shown in FIG. 10, for the set M levels and torque range of the knob, there is a relationship mapping with gradient-increasing feedback torque. It should be understood that, regardless of the reference torque-detent mapping curve of FIG. 15 or the reference torque-level mapping profile of FIG. 16, a relationship mapping with gradient-decreasing feedback torque or with a feedback torque varying in a predetermined trend can also be set, which is not limited in this embodiment.

[0113] For example, the control unit 140 may acquire a correspondence table of function objects and the detent-torque mapping relationship, and determine the detent-torque mapping relationship based on the function objects corresponding to the function object information. For example, different function objects may have different detent-torque mapping relationships.

[0114] For example, the function object information is associated with function objects, and the function objects are selected from a plurality of adjustable parameters. The plurality of adjustable parameters may be associated with the same component, or at least two of the adjustable parameters may be associated with different com-

ponents. For example, the knob 110 may be used to adjust multiple function objects of the same component, or to adjust multiple different function objects of multiple different components. For example, the function object information may be obtained by acquiring a user's selection of the function object (via user input such as touch screen input, voice input, key input, or the like).

[0115] Returning to FIG. 10, in some examples, the method 200 may also include performing the following operations by the control unit 140: identifying that the rotational position, the displacement, the angle or the radian generated by the single rotation operation exceeds a detent coverage of the torque combination, and configuring a first preset torque for portions of the single rotation operation where the rotational position, the displacement, the angle or the radian exceeds the detent coverage of the torque combination by the control unit 140. For example, the rotation operation may be limited to rotation within a relative maximum rotatable detent range, such as to rotation of no more than 10 detents, while the absolute maximum detent may be 100. In this step, by configuring the first preset torque for portions exceeding the detent coverage of the torque combination, users can be reminded that the relatively maximum rotatable detent for a single rotation has been reached.

[0116] In some examples, the first preset torque is consistent with an end torque of the torque combination, or a hand feeling provided by the first preset torque is consistent with that provided by the end torque of the torque combination. In this step, the user can be reminded that the relatively maximum rotatable detent for a single rotation has been reached by means of the first preset torque that is consistent with or approximately consistent in hand feeling with the end torque.

[0117] In some examples, the method 200 may further include performing, by the control unit 140, the following operations: detecting whether the single rotation operation is completed based on the characterization data; and after completion of the single rotation operation, controlling the torque output unit to provide zero torque or an initial torque or a second preset torque for the knob, wherein the second preset torque has a limiting and fixing effect on the knob, and the initial torque is an initial segment torque of the torque combination. For example, after completion of the single rotation operation, the control unit may remind the user that the single rotation operation is completed via tactile feedback by providing another torque (e.g., zero torque, or initial torque) different from the end torque, or can remind the user that the single rotation operation is completed via tactile feedback by a second preset torque that has a limiting and fixing effect on the knob.

[0118] The method 200 may further include performing the following operations by the control unit 140: determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation, and determining an ending detent of the single

rotation operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range. This step can prevent the rotation operation from exceeding the actual absolute detent range of the function object.

[0119] For example, determining the initial detent of the single rotation operation may include: if the single rotation operation of the knob 110 is the first operation, determining the initial detent as a third preset detent, or if the single rotation operation of the knob 110 is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.

[0120] The method 200 may further include performing the following operations by the control unit 140: if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent; generating control information for the limit detent based on the limit torque; and outputting a control signal to the torque output unit 120 based on the control information for the limit detent.

[0121] Turning to FIG. 17, an exemplary limit torque according to an embodiment of the present invention is shown. The knob 110 has a boundary stop or limit detent in at least one direction, and for the limit detent, limit torque feedback may be provided by a limit torque different from the reference torque used during torque adjustment. For example, a large limit torque feedback may be provided to limit further rotation by the user.

[0122] Turning to FIG. 11, another control method 300 for a knob assembly in accordance with the second embodiment of the present invention is shown. The method 300 may be executed by any one of the knob assembly 100 of FIG. 1, the knob assembly 300 of FIG. 18, or a knob assembly 410 of an in-vehicle apparatus or electronic device or appliance 400 of FIG. 20. As shown in FIG. 11, the method 300 includes steps 310-320. For example, the initial torque in the initial segment and the end torque in the final segment of the torque combination may not be the same, or at least one of the initial torque and the end torque may not be the same as the torque in the intermediate segment (between the initial segment and the final segment).

[0123] In step 310, the detection unit 130 detects a rotation operation of the knob 110 to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob 110, and transmits the characterization data to the control unit 140.

[0124] In step 320, the control unit 140 is provided with a torque combination, determines a beginning end and a finishing end of a single rotation operation based on the characterization data, and configures the torque combination based on the beginning end and/or the finishing end. For example, the configured torque combination may be one of the at least one torque combination. For example, the configured torque combination includes at least two different torques.

[0125] In some examples, the control unit 140 resets the torque configuration as the torque combination or configures the torque as an initial torque prior to the beginning end or subsequent to the finishing end. For example, the control unit may, after completion or before initiation of the single rotation operation, set the torque feedback of the knob 110 as the torque combination or as the initial torque to remind the user that the rotation is completed or initiated.

[0126] In some examples, a first duration threshold is set. The control unit 140 can identify the finishing end, and can reset the torque configuration as the torque combination or configure the torque as an initial torque after the first duration threshold has elapsed subsequent to a time point corresponding to the finishing end. For example, the control unit 140 can, after a delay subsequent to the completion of the single rotation operation, set the torque feedback of the knob as the torque combination or as the initial torque so as to remind the user of the completion of the rotation.

[0127] Similarly, the method 300 may also include one or more of the steps in the aforementioned method 200, and will not be described in detail.

[0128] FIG. 18 illustrates the structure of an exemplary knob assembly 300 according to an embodiment of the present invention. The knob assembly 300 may be, for example, the knob assembly 100 of FIG. 1, and is adapted to execute the above-described control method for the knob assembly.

[0129] FIG. 19 illustrates components of the knob assembly 300 of FIG. 18 in accordance with the first and second embodiments of the present invention. The knob assembly 300 includes a knob 310, a torque output unit 320, a detection unit 330, and a control unit (not shown). The knob 310 includes a rotation contact portion 311 located on sides of the knob 310, a screen assembly or touch portion 313 located on the top of the knob 310, and a transmission gear 312. The rotation contact portion 311 may be used for an operator to rotate the knob 310, and the screen assembly or the touch portion 313 may be used to display rotational state information or for touch control. The torque output unit 320 includes a motor 321 and a motor output gear 322. The transmission gear 312 of the knob 310 and the motor output gear 322 are engaged (e.g., meshed) such that the control unit controls the motor to output torque for transmission to the knob 310. The knob 310 and the torque output unit 320 may rotate together, but their rotational axes are not aligned. As the central hole of the motor is too small, if the motor is directly arranged coaxially with the central shaft of the knob, the wire harness of the screen assembly or the touch portion 313 cannot pass through the central hole of the motor. Therefore, by designing a set of the transmission gears, the transmission of the tactile function of the motor can be achieved, and the wire harness can be allowed to pass through the internal space of the knob (e.g., via hole 314). Meanwhile, this facilitates the use of a small-size motor to avoid exces-

sive space occupation. The detection unit 330 may be, for example, the aforementioned encoder or other sensors of similar function to detect the rotational state of the knob 310 or the torque output unit 320 (particularly, the motor 321).

[0130] It should be understood that, in other examples, the knob assembly according to the present invention may also be applied to a case where the rotational axis of the knob 310 and the rotational axis of the torque output unit 320 are aligned. Further, the torque output assembly is not limited to the motor 321 of FIG. 19, but may also be, for example, a controlled elastic member or other components with similar functions known in the art.

[0131] FIG. 20 shows an exemplary in-vehicle apparatus or electronic device or appliance 400 including a knob assembly according to the first and second embodiments of the present invention, and the in-vehicle apparatus or electronic device or appliance 400 may include the aforementioned knob assembly 100 or 300.

[0132] The present invention further provides a vehicle including the aforementioned knob assembly 100 or 300 or the aforementioned in-vehicle apparatus or electronic device or appliance 400.

[0133] Further, alternatively, the above-described method can be implemented by a computer-readable storage medium. The computer-readable storage medium has computer readable program instructions embodied thereon for performing the various embodiments of the present disclosure. The computer-readable storage medium may be a tangible device that can hold and store the instructions for use by the instruction execution device. The computer-readable storage medium may be, for example, but not limited to, an electrical memory device, a magnetic memory device, an optical memory device, an electromagnetic memory device, a semiconductor memory device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer-readable storage medium would include the following: a portable computer diskette, a hard disk, a Random Access Memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or flash memory), a Static Random Access Memory (SRAM), a portable compact disc read-only memory (CD-ROM), a Digital Versatile Disc (DVD), a memory stick, a floppy disk, a mechanical encoding device, punch cards or in-groove raised structures having, for example, instructions stored thereon, and any suitable combination of the foregoing. The computer-readable storage medium as used herein is not to be interpreted as a transitory signal per se, such as a radio wave or other freely propagating electromagnetic waves, an electromagnetic wave propagating through a waveguide or other transmission media (e.g., optical pulses through a fiber optic cable), or an electrical signal transmitted through an electrical wire.

[0134] Thus, in another embodiment, the present disclosure proposes a computer-readable storage medium having stored thereon computer-executable instructions

that, when executed by a processor, cause the processor to execute the methods in the various embodiments of the present disclosure.

[0135] It should be noted that the present invention (e.g., inventive concepts, etc.) has been described in the description of this patent document and/or illustrated in the drawings in accordance with exemplary embodiments; the embodiments of the present invention are presented by way of example only and are not intended as a limitation on the scope of the present invention. The construction and/or arrangement of the elements of the inventive concept embodied in the present invention, as described in the description and/or illustrated in the drawings, is illustrative only. Although exemplary embodiments of the present invention have been described in detail in this patent document, it will be readily understood by those of ordinary skill in the art that equivalents, modifications, variations, and the like of the subject matter of the exemplary embodiments and alternative embodiments are possible and are considered to be within the scope of the present invention; all such subject matter (e.g., modifications, variations, embodiments, combinations, equivalents, etc.) are intended to be included within the scope of the present invention. It should be further noted that various/other modifications, changes, substitutions, equivalents, variations, omissions, and the like may be made in the configuration and/or arrangement of the exemplary embodiments (for example, in terms of concepts, designs, structures, devices, forms, assemblies, constructions, means, functions, systems, processes/methods, steps, sequence of process/method steps, operations, operating conditions, properties, materials, compositions, combinations, and the like) without departing from the scope of the present invention; all such matters (e.g., modifications, variations, embodiments, combinations, equivalents, etc.) are intended to be included within the scope of the present invention. The scope of the present invention is not intended to be limited to the subject matter (e.g., the details, structures, functions, materials, acts, steps, sequences, systems, results, etc.) described in the description and/or the drawings of this patent document. It is contemplated that the claims of this patent document shall be appropriately interpreted to cover the full scope of the subject matter of the present invention (e.g., including any and all such modifications, variations, embodiments, combinations, equivalents, etc.); it is to be understood that the terminology used in the present patent document is for the purpose of providing a description of the subject matter of the exemplary embodiments, and is not intended to limit the scope of the present invention.

[0136] It is also noted that, according to exemplary embodiments, the present invention may include conventional techniques (e.g., techniques implemented and/or integrated in exemplary embodiments, modifications, variations, combinations, equivalents), or may include any other applicable techniques (now and/or in the future) capable of performing the functions and processes

ses/operations described in the description and/or illustrated in the drawings. All such techniques (e.g., techniques implemented in the embodiments, modifications, variations, combinations, equivalents, etc.) are deemed to be within the scope of the present invention as defined by the present patent document.

Claims

1. A knob assembly, comprising:

a knob, a torque output unit, a detection unit and a control unit;
the detection unit being electrically connected with the control unit, and the control unit controlling the torque output unit to provide a torque for the knob;
wherein,
the detection unit detects a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and transmits the characterization data to the control unit;
the control unit determines a rotation rate or velocity of the knob based on the characterization data,
the control unit, during the single rotation operation, dynamically adjusts the torque output unit based on the rotation rate or velocity to generate at least two torques for the knob in the single rotation operation.

2. The knob assembly according to claim 1, wherein dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques for the knob in the single rotation operation comprises:

determining a plurality of detents traversed during the single rotation operation based on the rotation rate or velocity, wherein the plurality of detents comprises at least a first detent segment and a second detent segment subsequent to the first detent segment; and
during the first detent segment:

generating first control information for the first detent segment based on a first reference torque; and
outputting a control signal to the torque output unit according to the first control information;
and during the second detent segment:

if the obtained rotation rate or velocity is higher than a rate or velocity threshold

range or a rate or velocity threshold value, generating second control information for the second detent segment based on a second reference torque different from the first reference torque; and
outputting a control signal to the torque output unit according to the second control information.

3. The knob assembly according to claim 2, wherein,

the plurality of detents further comprises a third detent segment between the first detent segment and the second detent segment; and
dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques for the knob in the single rotation operation comprises:
during the third detent segment:

generating third control information for the third detent segment based on a third reference torque between the first reference torque and the second reference torque; and
outputting a control signal to the torque output unit according to the third control information.

4. The knob assembly according to claim 2, wherein the control unit further performs:

during the second detent segment, if the obtained rotation rate or velocity is within the rate or velocity threshold range, or lower than the rate or velocity threshold range or the rate or velocity threshold value, then maintaining use of the first control information to control the torque output unit to provide the torque for the knob.

5. The knob assembly according to claim 2, wherein,

the plurality of detents further comprises a fourth detent segment subsequent to the second detent segment; and
dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques for the knob in the single rotation operation comprises:
during the fourth detent segment:

if the obtained rotation rate or velocity is lower than the rate or velocity threshold range or the rate or velocity threshold value, generating fourth control information for the fourth detent segment based on the first

- reference torque; and
outputting a control signal to the torque output unit according to the fourth control information.
6. The knob assembly according to claim 2, wherein a relative gradient relationship between the first reference torque and the second reference torque is based on a rotational direction.
7. The knob assembly according to claim 2, wherein,
the control unit further acquires function object information corresponding to the single rotation adjustment operation; and
at least one of the first reference torque, the second reference torque, and a relative gradient relationship between the first reference torque and the second reference torque is based on rotational direction data and/or the function object information.
8. The knob assembly according to any one of claims 2 to 7, wherein generating control information for the detent based on the reference torque comprises:
acquiring a torque profile for the detents based on the reference torque, wherein the torque profile comprises at least a positive output torque stage and a negative output torque stage; and
generating control information for the detents based on the torque profile.
9. The knob assembly according to claim 8, wherein the reference torque is a peak torque for the detent.
10. The knob assembly according to claim 1, wherein the control unit further performs:
detecting whether the single rotation operation is completed based on the characterization data;
after completion of the single rotation operation, controlling the torque output unit to provide zero torque or another preset torque for the knob.
11. The knob assembly according to claim 1, wherein the control unit further performs:
determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation;
determining an ending detent of the single rotation operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.
12. The knob assembly according to claim 11, wherein determining the initial detent of the single rotation operation comprises:
if the single rotation operation of the knob is the first operation, determining the initial detent as a preset detent, or
if the single rotation operation of the knob is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.
13. The knob assembly according to claim 11 or 12, wherein the control unit further performs:
if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent;
generating control information for the limit detent based on the limit torque; and
outputting a control signal to the torque output unit according to the control information for the limit detent.
14. The knob assembly according to claim 7, wherein the function object information is associated with a function object selected from a plurality of adjustable parameters, wherein the plurality of adjustable parameters is associated with the same component, or at least two of the adjustable parameters are associated with different components.
15. The knob assembly according to claim 1, wherein,
a rotational axis of the knob rotates together with the torque output unit; and
a rotational axis of the knob is aligned with a rotational axis of the torque output unit, or
a rotational axis of the knob is not aligned with a rotational axis of the torque output unit, and the knob and the torque output unit are connected by means of a transmission.
16. A knob assembly, comprising:
a knob, a torque output unit, a detection unit and a control unit;
the detection unit being electrically connected with the control unit, and the control unit being capable of controlling the torque output unit to provide a torque for the knob;
wherein,
the detection unit is configured to detect a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and to transmit the

characterization data to the control unit;
 the control unit is configured to determine a rotation rate or velocity of the knob based on the characterization data,
 the control unit is further configured to, during 5
 the single rotation operation, be capable of dynamically adjusting the torque output unit based on the rotation rate or velocity to generate at least two different torques or to provide an adjustable torque for the knob in the single rotation 10
 operation.

17. A control method for a knob assembly,

the knob assembly comprising a knob, a torque output unit, a detection unit and a control unit; 15
 the detection unit being electrically connected with the control unit, and the control unit controlling the torque output unit to provide a torque for the knob; 20
 wherein the method comprises the steps of:

detecting a single rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob and transmitting the characterization data to the control unit by the detection unit; 25
 determining a rotation rate or velocity of the knob based on the characterization data by the control unit, 30
 during the single rotation operation, dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to provide an adjustable torque for the knob in the single rotation 35
 operation.

18. The control method according to claim 17, wherein 40
 dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to provide the adjustable torque for the knob in the single rotation operation comprises: 45

determining a plurality of detents traversed during the single rotation operation based on the rotation rate or velocity, wherein the plurality of detents comprises at least a first detent segment and a second detent segment subsequent to the first detent segment; and 50
 during the first detent segment:

generating first control information for the first detent segment based on a first reference torque; and 55
 outputting a control signal to the torque output unit according to the first control information;

mation;
 and during the second detent segment:

if the obtained rotation rate or velocity is higher than a rate or velocity threshold range or a rate or velocity threshold value, generating second control information for the second detent segment based on a second reference torque different from the first reference torque; and
 outputting a control signal to the torque output unit according to the second control information.

19. The control method according to claim 18, wherein,

the plurality of detents further comprises a third detent segment between the first detent segment and the second detent segment; and
 dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to provide the adjustable torque for the knob in the single rotation operation comprises:
 during the third detent segment:

generating third control information for the third detent segment based on a third reference torque between the first reference torque and the second reference torque; and
 outputting a control signal to the torque output unit according to the third control information.

20. The control method according to claim 18, wherein 55
 the control unit further performs:
 during the second detent segment, if the obtained rotation rate or velocity is within the rate or velocity threshold range, or lower than the rate or velocity threshold range or the rate or velocity threshold value, then maintaining use of the first control information to control the torque output unit to provide the torque for the knob.

21. The control method according to claim 18, wherein,

the plurality of detents further comprises a fourth detent segment subsequent to the second detent segment; and
 dynamically adjusting the torque output unit based on the rotation rate or velocity by the control unit to generate the at least two torques for the knob in the single rotation operation comprises:
 during the fourth detent segment:

- if the obtained rotation rate or velocity is lower than the rate or velocity threshold range or the rate or velocity threshold value, generating fourth control information for the fourth detent segment based on the first reference torque; and
 5 outputting a control signal to the torque output unit according to the fourth control information.
- 22.** The control method according to claim 18, wherein a relative gradient relationship between the first reference torque and the second reference torque is based on a rotational direction.
- 23.** The control method according to claim 18, wherein,
 10 the control unit further acquires function object information corresponding to the single rotation adjustment operation; and
 at least one of the first reference torque, the second reference torque, and a relative gradient relationship between the first reference torque and the second reference torque is based on rotational direction data and/or the function object information.
- 24.** The control method according to any one of claims 18 to 23, wherein generating control information for the detent based on the reference torque comprises:
 20 acquiring a torque profile for the detents based on the reference torque, wherein the torque profile comprises at least a positive output torque stage and a negative output torque stage; and
 generating control information for the detents based on the torque profile.
- 25.** The control method according to claim 24, wherein the reference torque is a peak torque for the detent.
- 26.** The control method according to claim 17, wherein the control unit further performs:
 45 detecting whether the single rotation operation is completed based on the characterization data;
 after completion of the single rotation operation, controlling the torque output unit to provide zero torque or another preset torque for the knob.
- 27.** The control method according to claim 17, wherein the control unit further performs:
 50 determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation;
- determining an ending detent of the single rotation operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.
- 28.** The control method according to claim 27, wherein determining the initial detent of the single rotation operation comprises:
 10 if the single rotation operation of the knob is the first operation, determining the initial detent as a preset detent, or
 if the single rotation operation of the knob is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.
- 29.** The control method according to claim 27 or 28, wherein the control unit further performs:
 20 if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent;
 generating control information for the limit detent based on the limit torque; and
 outputting a control signal to the torque output unit according to the control information for the limit detent.
- 30.** The control method according to claim 23, wherein the function object information is associated with a function object selected from a plurality of adjustable parameters, wherein the plurality of adjustable parameters is associated with the same component, or at least two of the adjustable parameters are associated with different components.
- 31.** A knob assembly, comprising:
 40 a knob, a torque output unit, a detection unit and a control unit;
 the detection unit being electrically connected with the control unit, and the control unit controlling the torque output unit to provide a torque for the knob;
 wherein,
 45 the detection unit detects a rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian associated with rotation of the knob, and transmits the characterization data to the control unit;
 the control unit is provided with at least one torque combination,
 50 the control unit determines a single rotation operation based on the characterization data,

and configures the torque combination for the single rotation operation.

- 32.** The knob assembly according to claim 31, wherein, the control unit further determines whether the single rotation operation is completed based on the characterization data, and after completion of the single rotation operation, resets the torque configuration as the torque combination or configures the torque as an initial torque.

- 33.** The knob assembly according to claim 31, wherein, a first duration threshold is set, and the control unit resets a torque combination configuration or configures the torque as an initial torque after the first duration threshold has elapsed subsequent to completion of the single rotation operation.

- 34.** The knob assembly according to claim 31, wherein, the control unit further acquires or stores function object information corresponding to the knob; and configuring the torque combination for the single rotation operation by the control unit comprises: configuring the torque combination for the single rotation operation by the control unit based on the function object information.

- 35.** The knob assembly according to claim 34, wherein the function object information is associated with function objects, which have the same or different torque combinations for different rotational directions.

- 36.** The knob assembly according to claim 31, wherein, the control unit identifies one or more detents traversed during the single rotation operation based on the characterization data; and configuring the torque combination for the single rotation operation by the control unit comprises: for each of the one or more detents:

determining a reference torque for each detent;
generating control information for each detent based on the determined reference torque for each detent;
controlling the torque output unit to provide a torque for the knob according to the control information for each detent.

- 37.** The method according to claim 36, wherein the control unit identifies that the rotational position, the displacement, the angle or the radian generated by the single rotation operation exceeds a detent coverage of the torque combination, and the control

unit configures a first preset torque for portions of the single rotation operation where the rotational position, the displacement, the angle or the radian exceeds the detent coverage of the torque combination.

- 38.** The knob assembly according to claim 37, wherein the first preset torque is consistent with an end torque of the torque combination, or a hand feeling provided by the first preset torque is consistent with that provided by the end torque of the torque combination.

- 39.** The knob assembly according to claim 36, wherein determining the reference torque for each detent comprises:
based on a detent-torque mapping relationship, determining a reference torque for each detent.

- 40.** The knob assembly according to claim 39, wherein the detents are classified in terms of levels, and the detent-torque mapping relationship is determined according to a level-torque mapping relationship, and the number of the levels is less than or equal to the number of the detents.

- 41.** The knob assembly according to claim 39, wherein the control unit further performs:

acquiring a correspondence table of function objects and the detent-torque mapping relationship, and
determining the detent-torque mapping relationship based on the function objects corresponding to the function object information.

- 42.** The knob assembly according to any one of claims 36 to 41, wherein generating control information for each detent based on the determined reference torque for each detent comprises:

acquiring a torque profile for each detent based on the determined reference torque for each detent, wherein the torque profile comprises at least a positive output torque stage and a negative output torque stage;
generating control information for each detent based on the torque profile.

- 43.** The knob assembly according to claim 42, wherein the reference torque is a peak torque for each detent.

- 44.** The knob assembly according to claim 31, wherein the control unit further performs:

determining whether the single rotation operation is completed based on the characterization data; and

after completion of the single rotation operation, controlling the torque output unit to provide zero torque or an initial torque or a second preset torque for the knob, wherein the second preset torque has a limiting and fixing effect on the knob, and the initial torque is an initial segment torque of the torque combination.

45. The knob assembly according to claim 31, wherein the control unit further performs:

determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation;
determining an ending detent of the single rotation adjustment operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.

46. The knob assembly according to claim 45, wherein determining the initial detent of the single rotation adjustment operation comprises:

if the single rotation operation of the knob is the first operation, determining the initial detent as a third preset detent, or
if the single rotation operation of the knob is not the first operation, determining the initial detent as a historical ending detent of the previous historical operation of the single rotation operation.

47. The knob assembly according to claim 45 or 46, wherein the control unit further performs:

if the ending detent is a limit detent within the detent range, determining a limit torque for the limit detent;
generating control information for the limit detent based on the limit torque; and
controlling the torque output unit to provide a torque for the knob according to the control information for the limit detent.

48. The knob assembly according to claim 34, wherein a function object corresponding to the function object information is selected from a plurality of adjustable parameters, wherein the plurality of adjustable parameters is associated with the same component, or at least two of the adjustable parameters are associated with different components.

49. The knob assembly according to claim 31, wherein,

the knob is capable of rotating together with the torque output unit; and
a rotational axis of the knob is aligned with a

rotational axis of the torque output unit, or
a rotational axis of the knob is not aligned with a rotational axis of the torque output unit, and the knob and the torque output unit are connected by means of a transmission.

50. The knob assembly according to claim 31, wherein the torque combination comprises at least two different torques.

51. A control method for a knob assembly,

the knob assembly comprising a knob, a torque output unit, a detection unit, and a control unit; the detection unit being electrically connected with the control unit, and the control unit controlling the torque output unit to provide a torque for the knob;
wherein the method comprises the steps of:

detecting a rotation operation of the knob to obtain characterization data indicating a rotational position, a displacement, an angle or a radian of the knob, and transmitting the characterization data to the control unit by the detector,
providing the control unit with a torque combination;
determining a beginning end and a finishing end of a single rotation operation based on the characterization data, and configuring the torque combination based on the beginning end and/or the finishing end by the control unit.

52. The control method according to claim 51, wherein, the control unit resets the torque configuration as the torque combination or configures the torque as an initial torque prior to the beginning end or subsequent to the finishing end.

53. The control method according to claim 51, wherein, a first duration threshold is set; and the control unit identifies the finishing end and, after the first duration threshold has elapsed subsequent to a time point corresponding to the finishing end, resets the torque configuration as the torque combination or configures the torque as an initial torque.

54. The control method according to claim 51, wherein,

the control unit further acquires or stores function object information corresponding to the knob; and
configuring the torque combination by the control unit comprises: configuring the torque combination for the single rotation operation based on the function object information by the control

unit.

55. The control method according to claim 54, wherein the function object information is associated with function objects, which have the same or different torque combinations for different rotational directions.

56. The control method according to claim 51, wherein,

the control unit identifies one or more detents traversed during the single rotation operation based on the characterization data; and configuring the torque combination for each of the single rotation operations by the control unit comprises:

for each of the one or more detents:

determining a reference torque for each detent;

generating control information for each detent based on the determined reference torque for each detent;

controlling the torque output unit to provide a torque for the knob according to the control information for each detent.

57. The control method according to claim 56, wherein the control unit identifies that the rotational position, the displacement, the angle or the radian generated by the single rotation operation exceeds a detent coverage of the torque combination, and the control unit configures a first preset torque for portions of the single rotation operation where the rotational position, the displacement, the angle or the radian exceeds the detent coverage of the torque combination.

58. The control method according to claim 57, wherein the first preset torque is consistent with an end torque of the torque combination, or a hand feeling provided by the first preset torque is consistent with that provided by the end torque of the torque combination.

59. The control method according to claim 56, wherein determining the reference torque for each detent comprises:

based on a detent-torque mapping relationship, determining a reference torque for each detent.

60. The control method according to claim 59, wherein the detents are classified in terms of levels, and the detent-torque mapping relationship is determined according to a level-torque mapping relationship, and the number of the levels is less than or equal to the number of the detents.

61. The control method according to claim 59, wherein the control unit further performs:

acquiring a correspondence table of function objects and the detent-torque mapping relationship, and

determining the detent-torque mapping relationship based on the function objects corresponding to the function object information.

62. The control method according to any one of claims 56 to 61, wherein generating control information for each detent based on the determined reference torque for each detent comprises:

acquiring a torque profile for each detent based on the determined reference torque for each detent, wherein the torque profile comprises at least a positive output torque stage and a negative output torque stage;

generating control information for each detent based on the torque profile.

63. The control method according to claim 62, wherein the reference torque is a peak torque for each detent.

64. The control method according to claim 51, wherein the control unit further performs:

determining whether the single rotation operation is completed based on the characterization data; and

after completion of the single rotation operation, controlling the torque output unit to provide zero torque or an initial torque or a second preset torque for the knob, wherein the second preset torque has a limiting and fixing effect on the knob, and the initial torque is an initial segment torque of the torque combination.

65. The control method according to claim 51, wherein the control unit further performs:

determining an initial detent of the single rotation operation and one or more detents traversed during the single rotation operation;

determining an ending detent of the single rotation adjustment operation based on the initial detent and the one or more detents traversed, wherein the ending detent is limited within an allowable detent range.

66. The control method according to claim 65, wherein determining the initial detent of the single rotation adjustment operation comprises:

if the single rotation operation of the knob is the first operation, determining the initial detent as a

third preset detent, or
 if the single rotation operation of the knob is not
 the first operation, determining the initial detent
 as a historical ending detent of the previous
 historical operation of the single rotation operation. 5

67. The control method according to claim 65 or 66,
 wherein the control unit further performs: 10

if the ending detent is a limit detent within the
 detent range, determining a limit torque for the
 limit detent;
 generating control information for the limit detent
 based on the limit torque; and 15
 controlling the torque output unit to provide a
 torque for the knob according to the control
 information for the limit detent.

68. The control method according to claim 54, wherein a 20
 function object corresponding to the function object
 information is selected from a plurality of adjustable
 parameters, wherein the plurality of adjustable para-
 meters is associated with the same component, or at
 least two of the adjustable parameters are asso- 25
 ciated with different components.

69. The control method according to claim 51, wherein
 the torque combination comprises at least two dif- 30
 ferent torques.

70. An in-vehicle apparatus or electronic device or ap-
 pliance, comprising the knob assembly according to
 any one of claims 1 to 16 and 31 to 50. 35

71. A computer-readable storage medium comprising
 computer instructions stored thereon, wherein the
 computer instructions, when executed by a proces-
 sor, cause the processor to execute the control
 method for a knob assembly according to any one 40
 of claims 17 to 30 and 51 to 69.

72. A vehicle, comprising the knob assembly according
 to any one of claims 1 to 16 and 31 to 50 or the in-
 vehicle apparatus or electronic device or appliance 45
 according to claim 70.

50

55

100

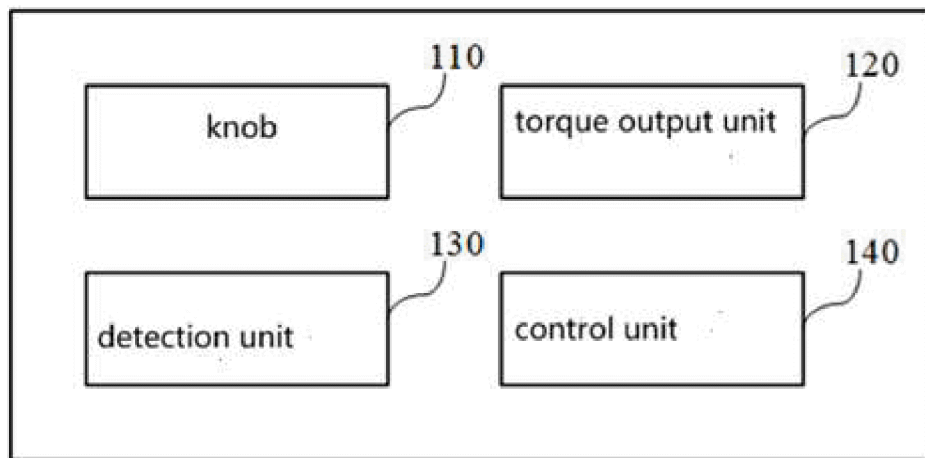


FIG. 1

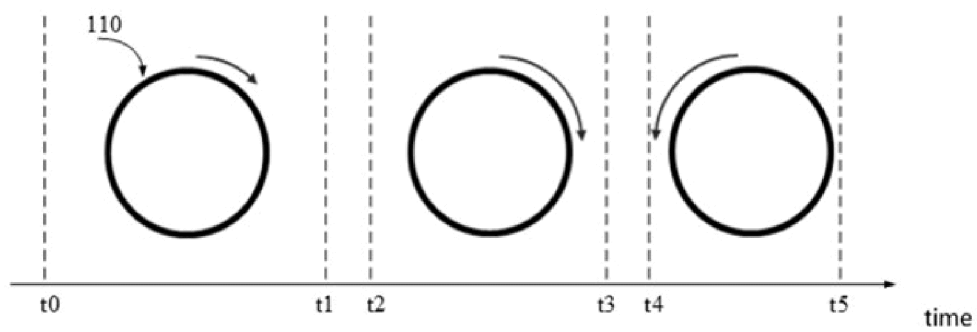


FIG. 2

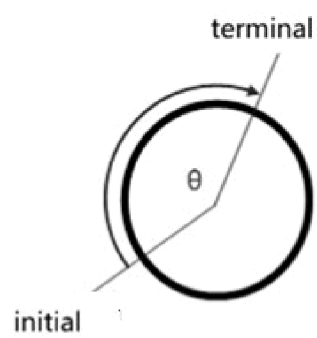


FIG. 3

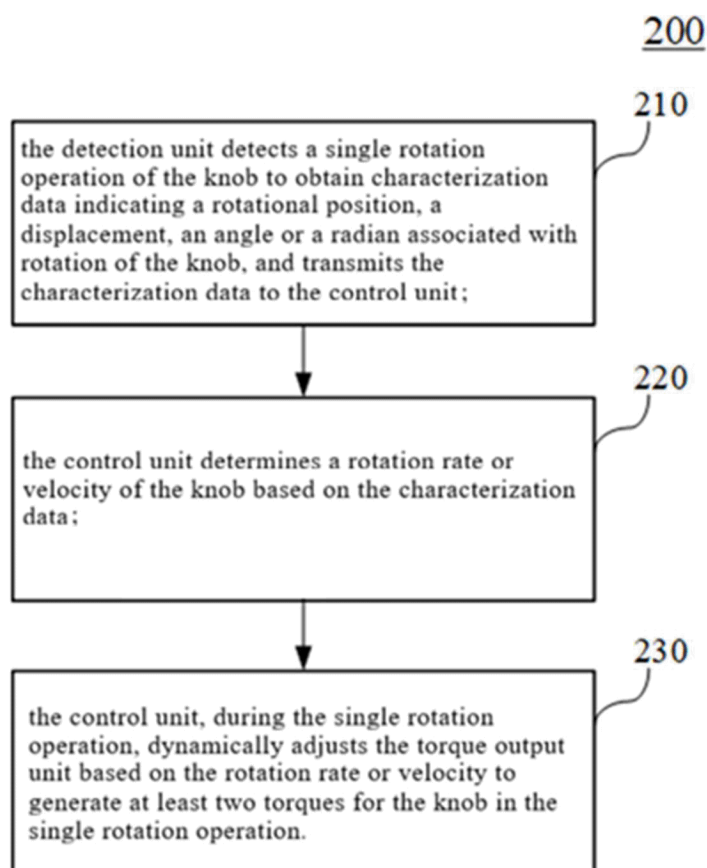


FIG. 4

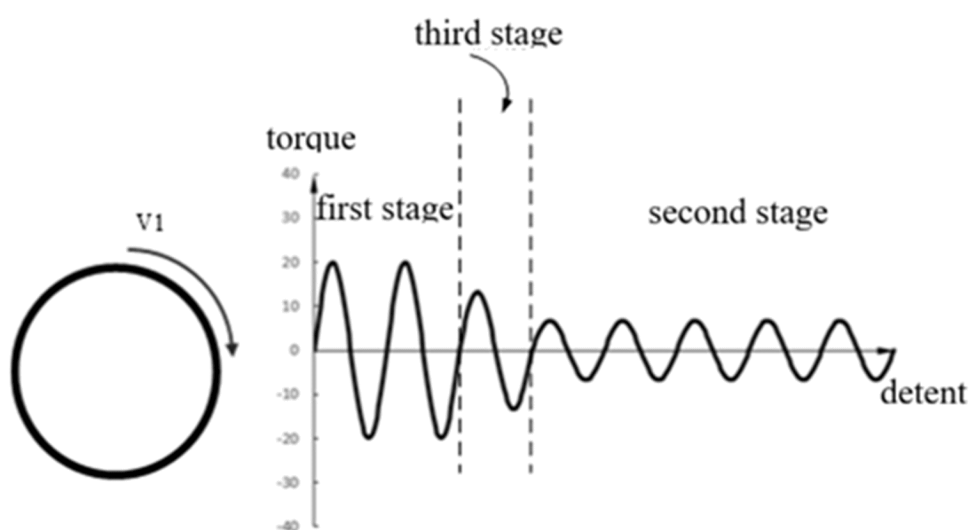


FIG. 5

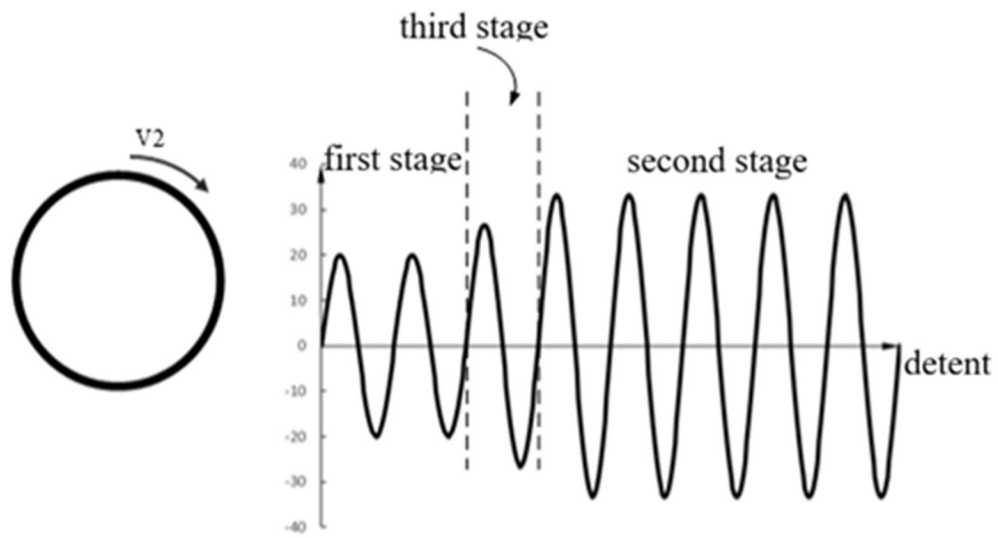


FIG. 6

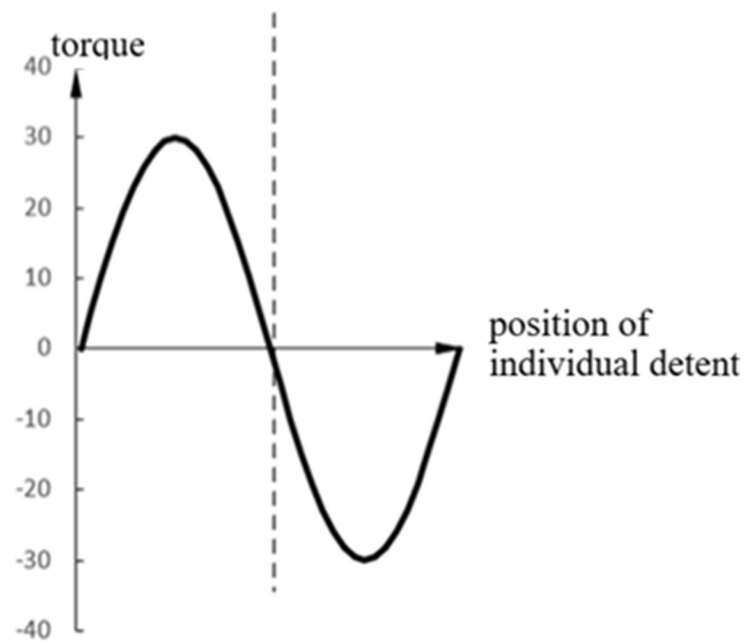


FIG. 7

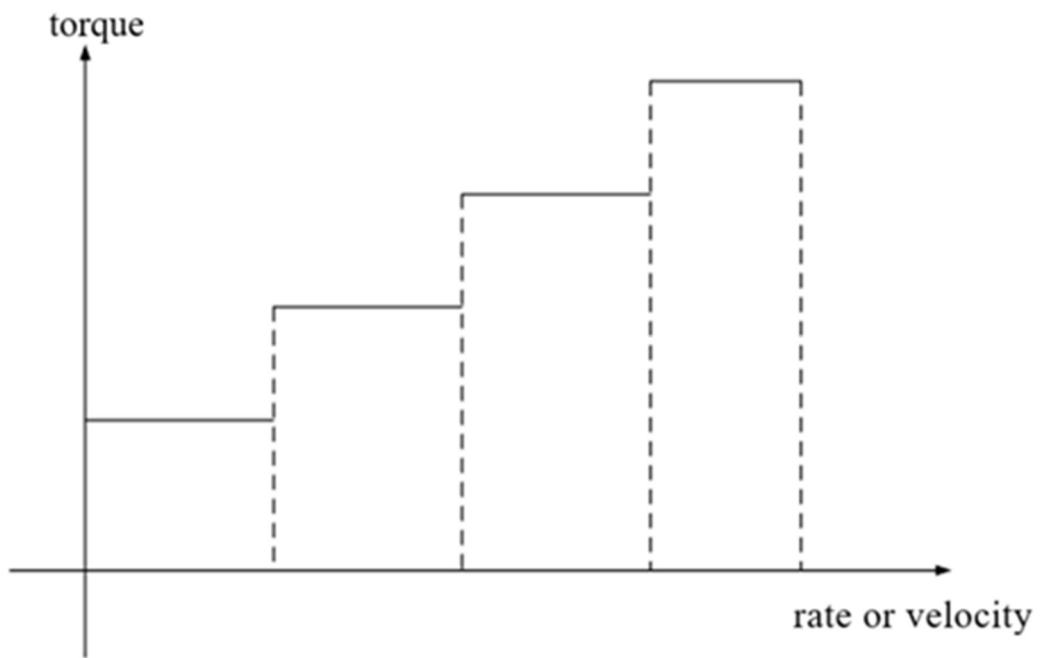


FIG. 8

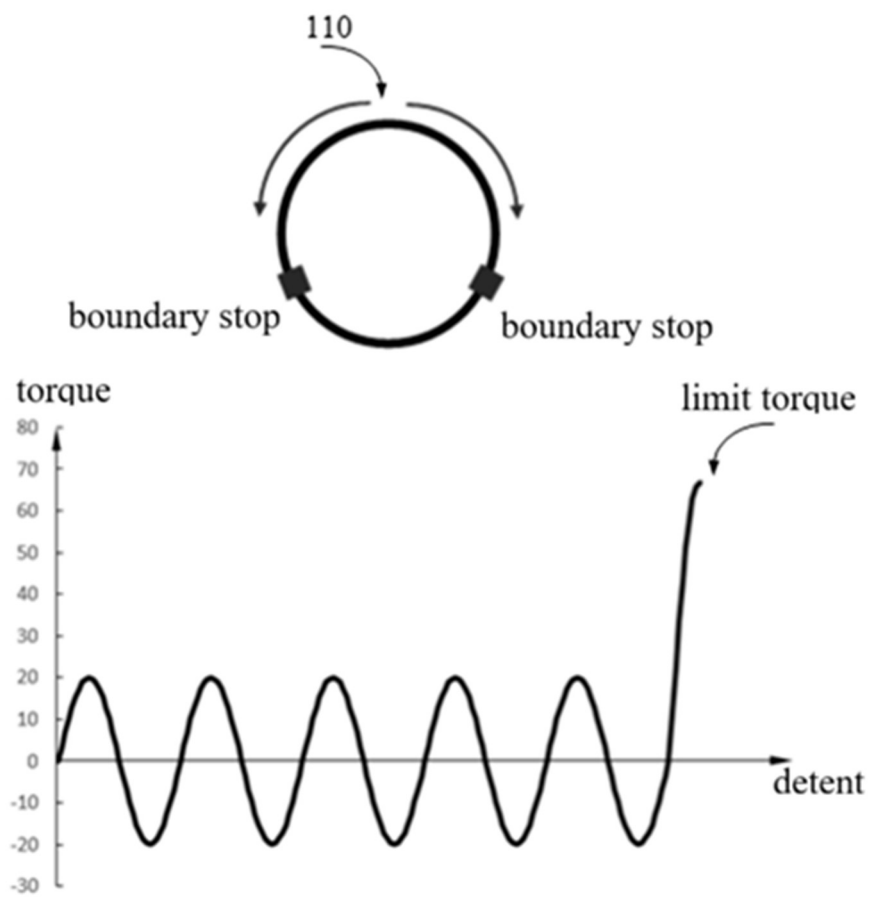


FIG. 9

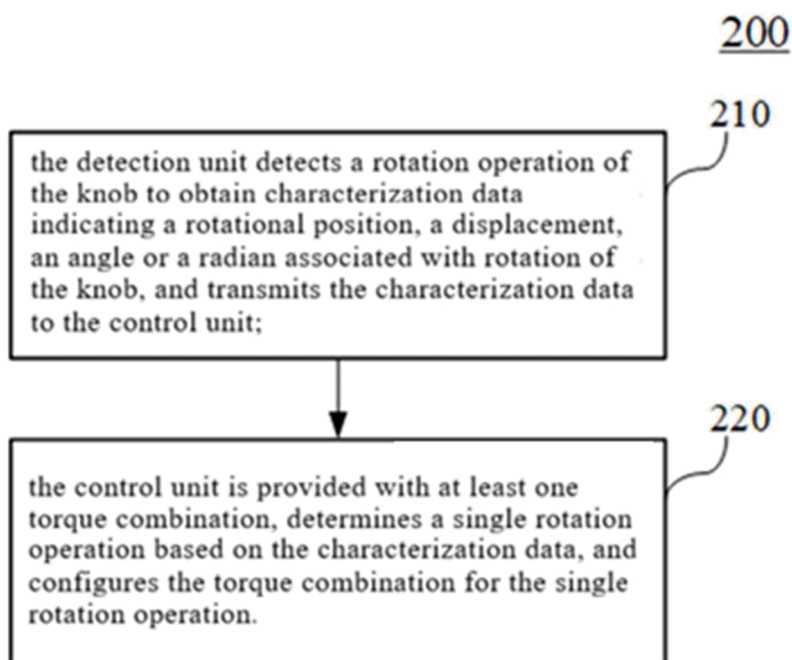


FIG. 10

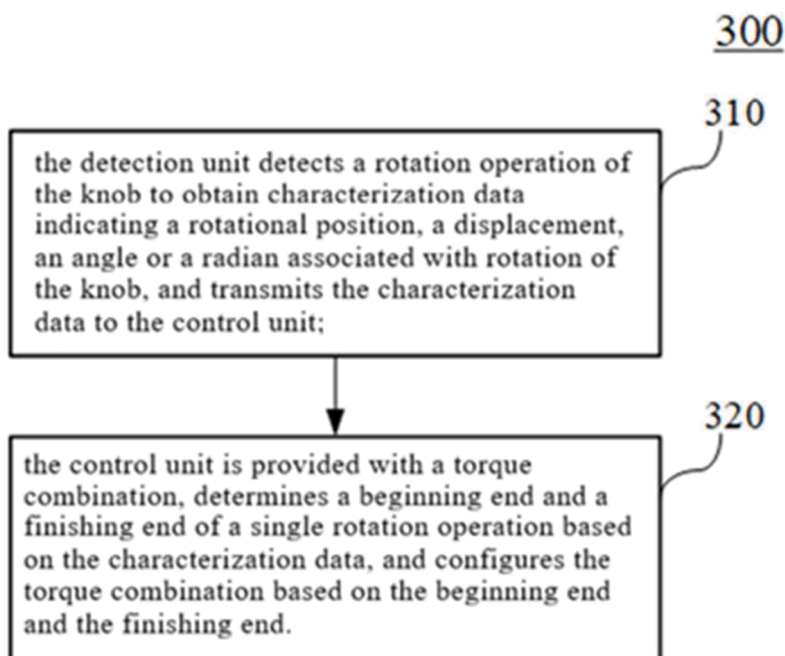


FIG. 11

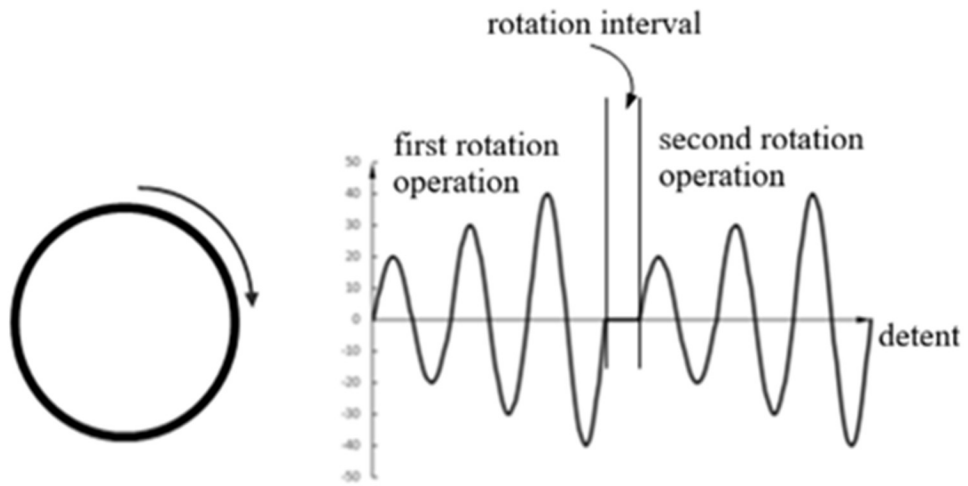


FIG. 12

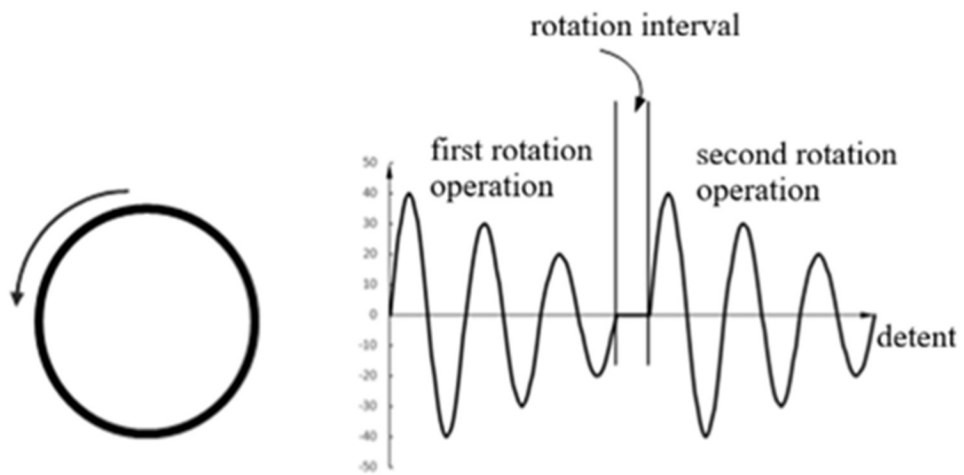


FIG. 13

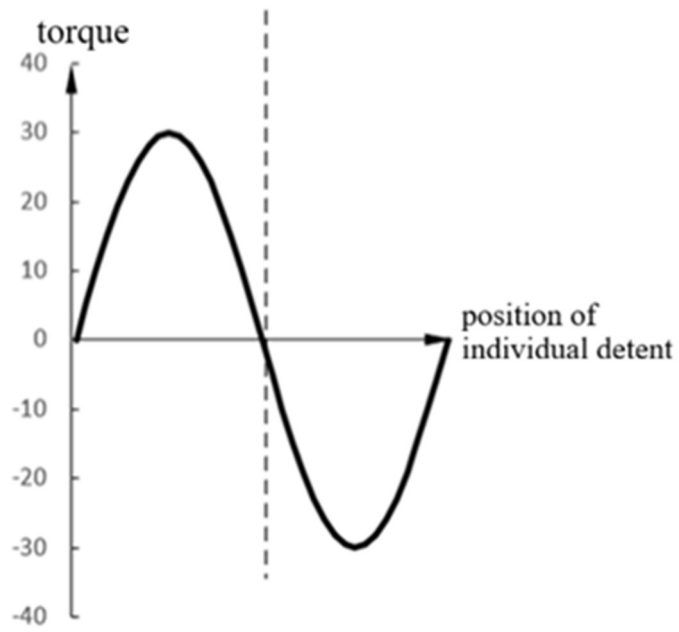


FIG. 14

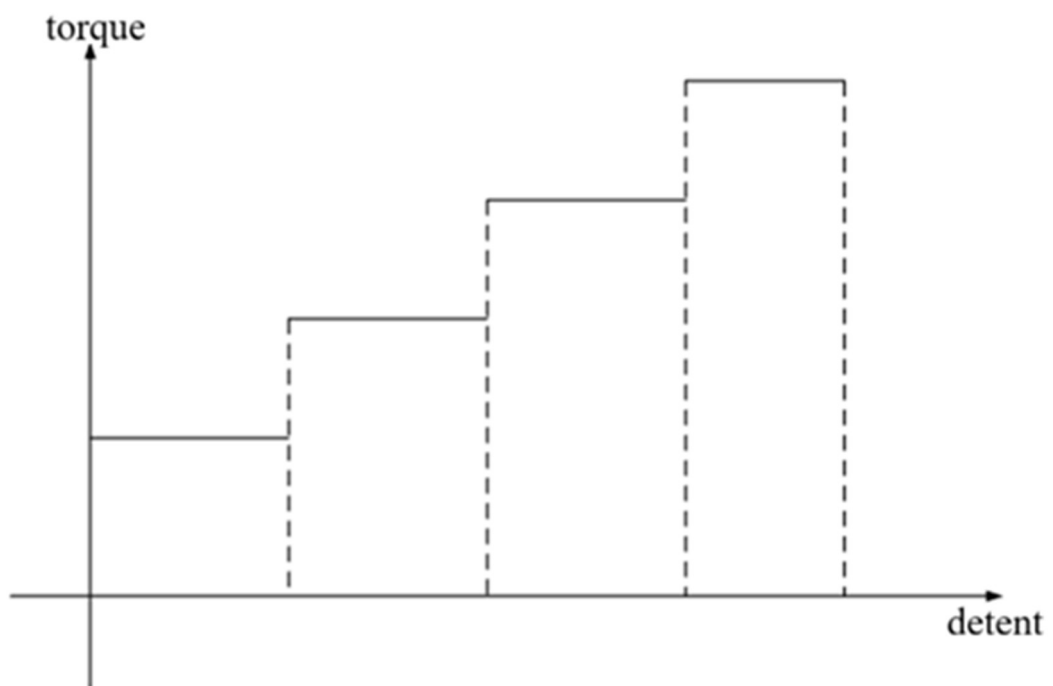


FIG. 15

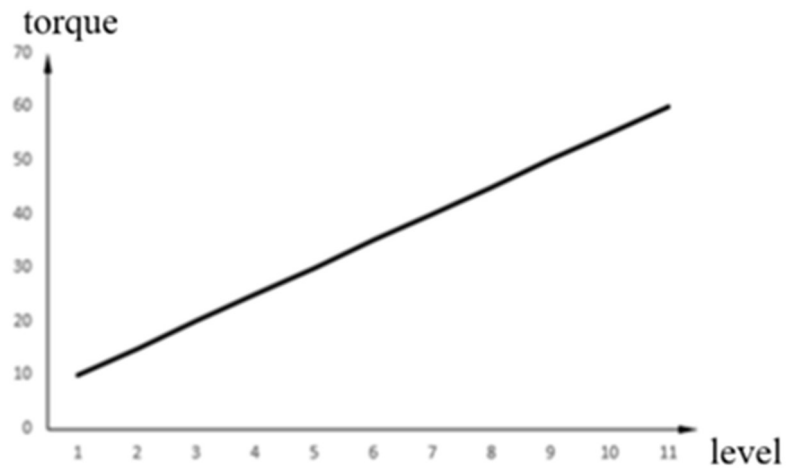
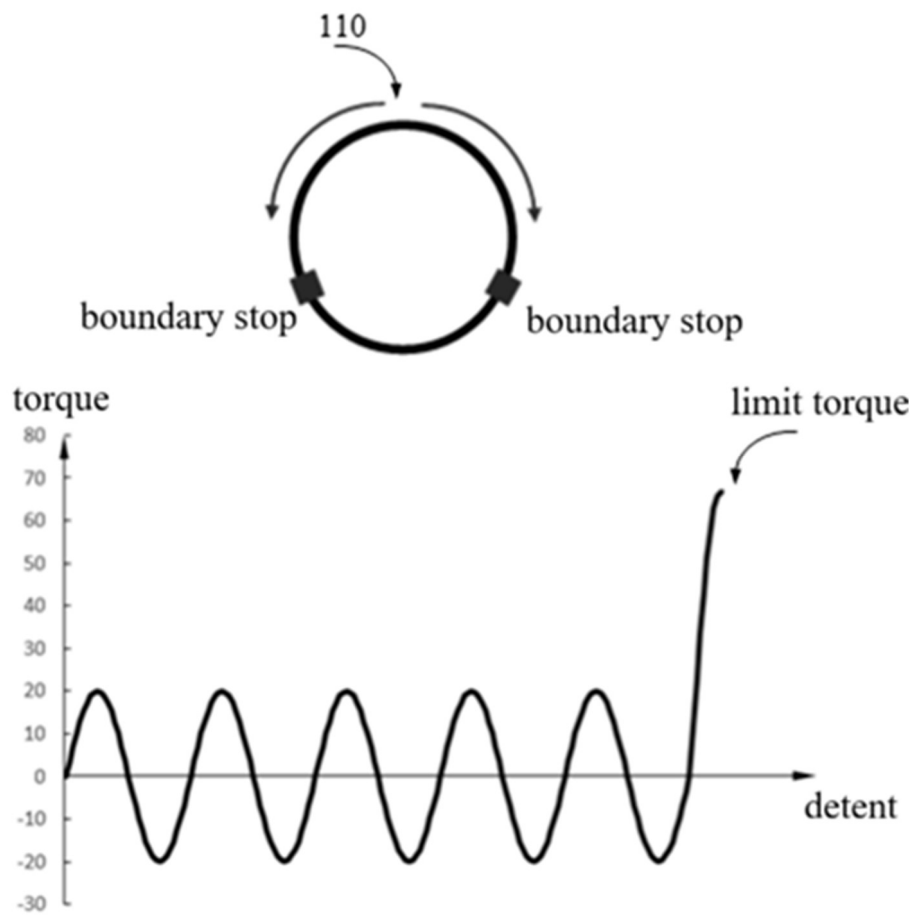


FIG. 16



300

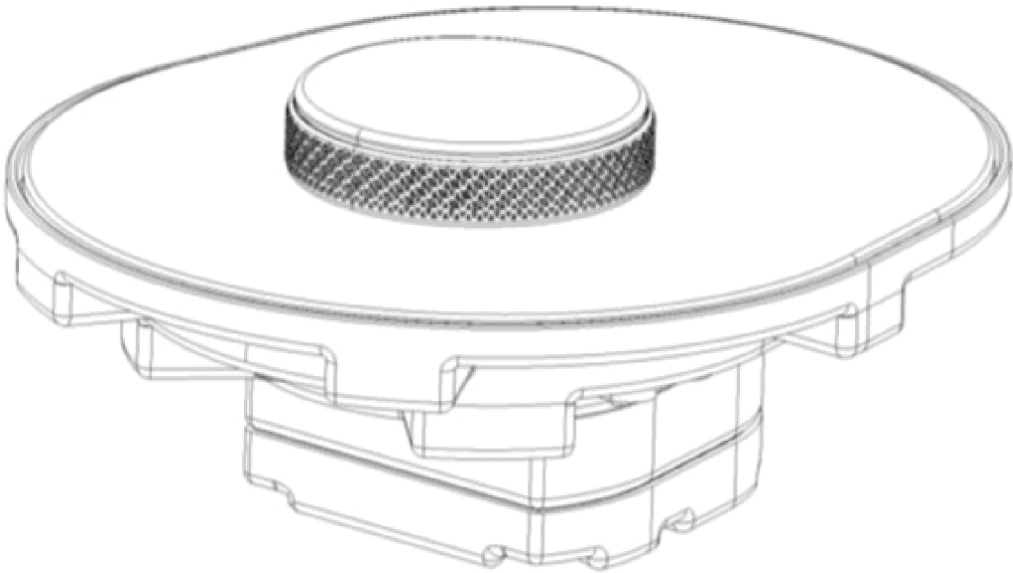


FIG. 18

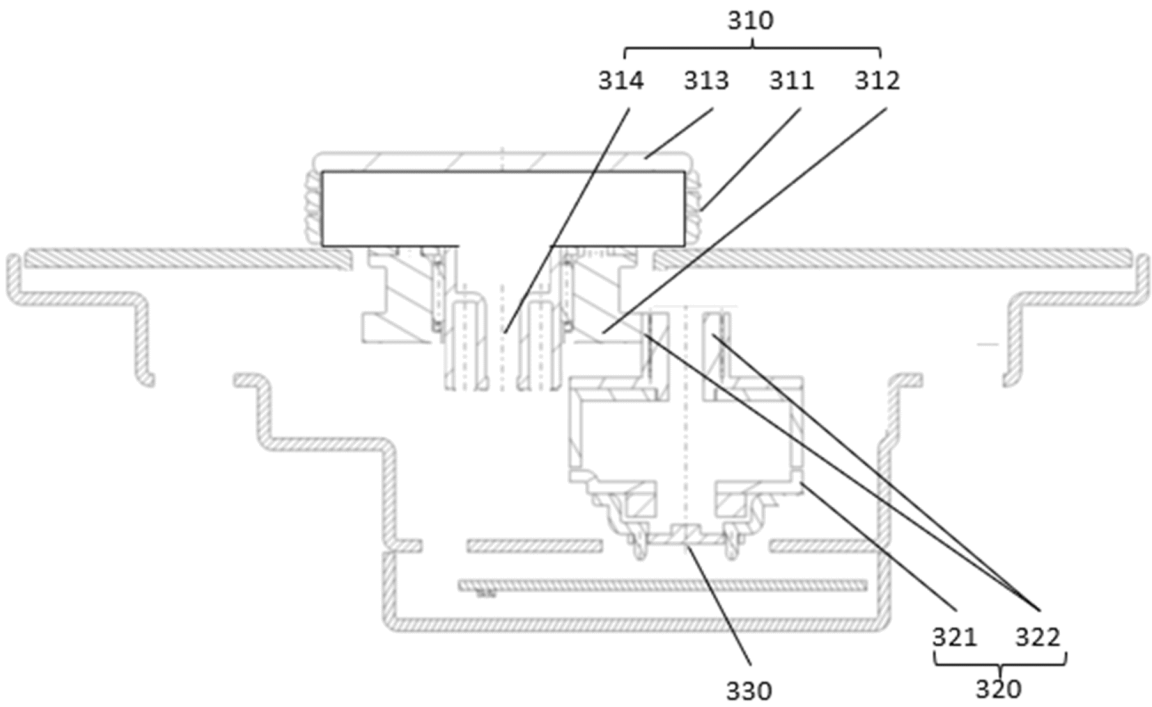


FIG. 19

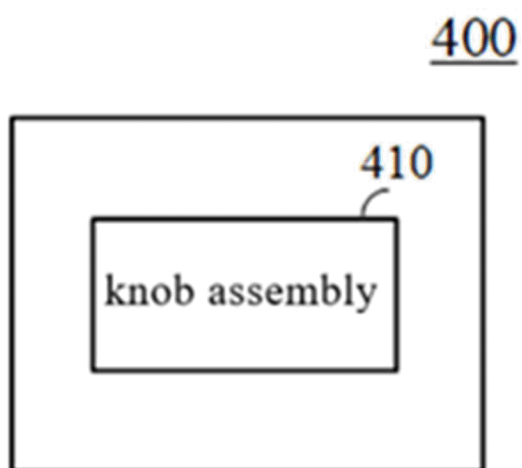


FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/135163

A. CLASSIFICATION OF SUBJECT MATTER

G05G 1/10(2006.01)i

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)

IPC: G05B; H01H

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)

CNTXT, DWPI, CJFD, WPABS, ENTXT: 旋钮, 旋转, 开关, 扭矩, 控制, 检测, 档位, knob, gear?, rotat+, switch, control+, detect+, rotary, torque

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 112863917 A (SHANGHAI KESHIDA-HUAYANG AUTOMOBILE ELECTRICAL APPLIANCE CO., LTD. et al.) 28 May 2021 (2021-05-28) description, paragraphs 0039-0087, and figures 1-2	1, 10-11, 15-17, 26-27, 31-35, 44-45, 48-55, 64-65, 68-72
Y	CN 214279852 U (NINGBO PREH JOYSON AUTOMOTIVE ELECTRONICS CO., LTD. et al.) 24 September 2021 (2021-09-24) description, paragraphs 0025-0029, and figures 1-4	1, 10-11, 15-17, 26-27, 31-35, 44-45, 48-55, 64-65, 68-72
A	CN 110770675 A (ZF FRIEDRICHSHAFEN AG) 07 February 2020 (2020-02-07) entire document	1-72
A	CN 210119723 U (BAIC MOTOR CORP., LTD.) 28 February 2020 (2020-02-28) entire document	1-72
A	CN 217544443 U (NINGBO PREH JOYSON AUTOMOTIVE ELECTRONICS CO., LTD. et al.) 04 October 2022 (2022-10-04) entire document	1-72
A	JP 2018052163 A (PANASONIC IP MANAGEMENT CORP.) 05 April 2018 (2018-04-05) entire document	1-72

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 13 March 2025	Date of mailing of the international search report 19 March 2025
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2024/135163

5
10
15
20
25
30
35
40
45
50
55

Patent document cited in search report			Publication date (day/month/year)		Patent family member(s)			Publication date (day/month/year)	
CN	112863917	A	28 May 2021		None				
CN	214279852	U	24 September 2021		None				
CN	110770675	A	07 February 2020		EP	3642688	A1	29 April 2020	
					DE	102017210439	A1	27 December 2018	
					WO	2018233972	A1	27 December 2018	
					US	2020148061	A1	14 May 2020	
CN	210119723	U	28 February 2020		None				
CN	217544443	U	04 October 2022		None				
JP	2018052163	A	05 April 2018		US	2018087657	A1	29 March 2018	
					US	10539226	B2	21 January 2020	
					JP	6671038	B2	25 March 2020	

Form PCT/ISA/210 (patent family annex) (July 2022)