

METHOD FOR PREDICTING HINGE TORQUE PERFORMANCE, APPARATUS,
COMPUTER DEVICE AND STORAGE MEDIUM

FIELD

[0001] The subject matter herein generally relates to a field of hinge technology, and in
5 particular to a method for predicting hinge torque performance, an apparatus, a computer device,
and a storage medium.

BACKGROUND

[0002] A hinge structure of a foldable electronic device (e.g., a foldable phone) is a core
component that determines torque during the opening and closing process of the foldable
10 electronic device. The design of the cams and springs in the hinge structure determines the torque
feedback during the opening and closing process of the foldable phone. The torque graph, as a
quantitative indicator of torque feedback, may intuitively judge folding feel of the foldable phone,
such as the torque required to open/close the foldable phone and a hovering angle, etc. In existing
designs, it is necessary to convert a planar design of the cams into a 3D model, then input
15 mechanical and geometric parameters of the hinge structure into simulation software to calculate
the torque and output the torque-rotation angle curve, which suffers from inefficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The above and/or additional aspects and advantages of the present disclosure will

become apparent and easily understood from the description of the embodiments below in conjunction with the accompanying drawings.

[0004] FIG. 1 is a flowchart of a method for predicting hinge torque performance provided by an embodiment of the present disclosure.

5 **[0005]** FIG. 2 is a schematic diagram of a first model and a second model provided in an embodiment of the present disclosure.

[0006] FIG. 3 is a schematic diagram of meshing between the first model and the second model provided in an embodiment of the present disclosure.

[0007] FIG. 4 is another schematic diagram of meshing between the first model and the
10 second model provided in an embodiment of the present disclosure.

[0008] FIG. 5 is a detailed flowchart for determining meshing positions during the rotation process of the hinge provided by an embodiment of the present disclosure.

[0009] FIG. 6 is a schematic diagram of hinge torque provided by an embodiment of the present disclosure.

15 **[0010]** FIG. 7 is a schematic diagram for reselecting a first target point on the first model provided by an embodiment of the present disclosure.

[0011] FIG. 8 is a schematic diagram of reselecting a first target point on the first model based on a binary interpolation method provided by an embodiment of the present disclosure.

[0012] FIG. 9 is a detailed flowchart for reselecting a second target point on the second model provided by an embodiment of the present disclosure.

[0013] FIG. 10 is a functional block diagram of an apparatus for acquiring hinge torque performance provided by an embodiment of the present disclosure.

5 [0014] FIG. 11 is a structural schematic diagram of a computer device provided by an embodiment of the present disclosure.

SUMMARY

[0015] Embodiments of the present application disclose a method for predicting hinge torque performance, an apparatus, a computer device, and a storage medium, which may reduce
10 computational load.

[0016] In a first aspect, an embodiment of the present application provides a method for predicting hinge torque performance. The method includes: constructing a plane model of a concave and convex cam set based on structural data of a hinge, wherein the plane model comprises a first model that represents a first profile of a first concave and convex cam of the
15 concave and convex cam set, a second model that represents a second profile of a second concave and convex cam of the concave and convex cam set, and mechanical parameters of the hinge; determining a plurality of meshing positions of the first model and the second model to construct a meshing point set, wherein the meshing positions are determined based on the first concave

and convex cam and the second concave and convex cam during a rotation process of the hinge; determining a correspondence relationship between a torque and a hinge rotation angle at a meshing point of the meshing point set based on the mechanical parameters of the hinge, and determining torque performance of the hinge based on the correspondence relationship.

5 **[0017]** In some embodiments of the present application, the constructing the plane model of the concave and convex cams set comprises: constructing the first model by dividing the first profile into alternately distributed first linear segments and first curved segments; constructing the second model by dividing the second profile into alternately distributed second linear segments and second curved segments.

10 **[0018]** In some embodiments of the present application, the determining the plurality of meshing positions of the first model and the second model to construct the meshing point set comprises: determining the meshing positions during the rotation process of the hinge according to contour line slopes of the first model and the second model; and setting points on the first model at the meshing positions as the meshing points to construct the meshing point set, or
15 setting points on the second model at the meshing positions as the meshing points to construct the meshing point set.

[0019] In some embodiments of the present application, the determining the meshing positions during the rotation process of the hinge according to contour line slopes of the first model and the second model comprises: determining a first reference point and a second

reference point by acquiring a slope of a point on the first model and the second model; selecting a first target point on the first model along the rotation direction of the hinge, and selecting a second target point on the second model along the rotation direction of the hinge; in response that a first slope of a line from the first reference point to the first target point is equal to a second slope of a line from the second reference point to the second target point, setting a location of the first target point or the second target point as the meshing position; in response that the first slope is greater than the second slope, setting the first model as a meshing search area, and reselecting the first target point on the first model along the rotation direction of the hinge to make the first slope equal the second slope; in response that the first slope is less than the second slope, setting the second model as the meshing search area, and reselecting the second target point on the second model along the rotation direction of the hinge to make the first slope equal the second slope.

[0020] In some embodiments of the present application, the reselecting the first target point on the first model along the rotation direction of the hinge comprises: reselecting the first target point on the first model based on a binary interpolation method to make the first slope equal the second slope; wherein the reselecting the second target point on the second model along the rotation direction of the hinge comprises: reselecting the second target point on the second model through the binary interpolation method to make the first slope and the second slope equal.

[0021] In some embodiments of the present application, the reselecting the first target point

on the first model through the binary interpolation method comprises: Step 11, selecting a third reference point behind the first target point along the rotation direction of the hinge; Step 12: setting a midpoint of a linear segment between the first reference point and the first target point as a first midpoint, setting a midpoint of a linear segment between the first target point and the third reference point as a second midpoint, determining a third slope of a linear segment between the first midpoint and the second midpoint, and comparing the third slope with the second slope; Step 13: in response that the third slope is equal to the second slope, updating the third reference point to be the first target point; Step 14: in response that the third slope is greater than the second slope, updating the first midpoint to be the first reference point, and updating the second midpoint to be the first target point, and returning to Step 12; Step 15: in response that the third slope is less than the second slope, updating the first midpoint to be the first target point, and updating the second midpoint to be the third reference point, and returning to Step 12; wherein the reselecting the second target point on the second model through the binary interpolation method comprises: Step 21: selecting a fourth reference point behind the second target point along the rotation direction of the hinge; Step 22: setting the midpoint of the linear segment between the second reference point and the second target point as a third midpoint, setting the midpoint of the linear segment between the second target point and the fourth reference point as a fourth midpoint, and comparing a fourth slope of a line between the third midpoint and the fourth midpoint with the first slope; Step 23: in response that the fourth slope is equal to the first slope,

updating the fourth reference point to be the second target point; Step 24: in response that the fourth slope is greater than the first slope, updating the third midpoint to be the second reference point, and updating the fourth midpoint to be the second target point, and returning to Step 22.

[0022] In some embodiments of the present application, the determining a correspondence

5 relationship between a torque and a hinge rotation angle at the meshing point of the meshing point set based on the mechanical parameters of the hinge comprises: acquiring the hinge rotation angle at the meshing point, a spring force at the meshing point, a friction coefficient between the first concave and convex cam and the second concave and convex cam, and a slope angle of the first concave and convex cam and the second concave and convex cam at the meshing point;
10 constructing the correspondence relationship between the torque and the hinge rotation angle by acquiring the torque at the meshing point according to the hinge rotation angle, the spring force, the friction coefficient, and the slope angle

[0023] In a second aspect, the present application provides an apparatus for acquiring hinge

torque performance comprising: a processing module, configured to construct a plane model of
15 a set of concave and convex cams based on structural data of a hinge, wherein the plane model comprises a first model that represents a first profile of a first concave and convex cam of the concave and convex cam set, a second model that represents a second profile of a second concave and convex cam of the concave and convex cam set, and mechanical parameters of the hinge; a determining module, configured to determine a plurality of meshing positions of the first model

and the second model to construct a meshing point set, wherein the meshing positions are determined based on the first concave and convex cam and the second concave and convex cam during a rotation process of the hinge; an acquiring module, configured to determine a correspondence relationship between a torque and a hinge rotation angle at a meshing point of the meshing point set based on the mechanical parameters of the hinge, and determining torque performance of the hinge based on the correspondence relationship.

[0024] In a third aspect, the present application provides a computer device comprising a storage device, at least one processor, and the storage device storing one or more programs that, when executed by the at least one processor, cause the at least one processor to execute a method.

[0025] In a fourth aspect, the present application provides a non-transitory storage medium having instructions stored thereon, when the instructions are executed by a processor of a computer device, the processor is caused to perform a method.

[0026] The method for predicting hinge torque performance provided by the embodiments of the present disclosure, based on structural data of a hinge, constructs a plane model including a first model and a second model; determines meshing positions of the first model and the second model to construct a meshing point set; determines a correspondence relationship between torque at meshing points in the meshing point set and a hinge rotation angle based on mechanical parameters of the hinge, and determines torque performance of the hinge based on the correspondence relationship. The torque performance of the hinge may be characterized through

the plane model of the hinge, reducing computational load and improving accuracy.

DETAILED DESCRIPTION

[0027] For ease of understanding, some concepts related to embodiments of the present disclosure are exemplarily provided for reference.

[0028] It should be noted that “at least one” in the disclosure refers to one or more, and “multiple” refers to two or more than two. “And/or” describes an association relationship of associated objects, indicating that there can be three relationships, for example, A and/or B may mean: A alone, both A and B, or B alone, where A and B may be singular or plural. The terms “first,” “second,” “third,” “fourth,” etc. (if present) in the description, claims, and drawings of the present disclosure are used to distinguish similar objects and not to describe a specific order or sequence.

[0029] In the embodiments of the present disclosure, words such as “exemplary” or “for example” are used to indicate examples, illustrations, or explanations. Any embodiment or design solution described as “exemplary” or “for example” in the embodiments of the present disclosure should not be construed as more preferred or advantageous than other embodiments or design solutions. Rather, the use of words such as “exemplary” or “for example” is intended to present related concepts in a specific manner. In the absence of conflict, the embodiments described below and the features in the embodiments may be combined with each other.

[0030] As shown in FIG. 1, it is a flowchart of a method for predicting hinge torque performance provided by an embodiment of the present disclosure.

[0031] In one embodiment of the present disclosure, the method for predicting hinge torque performance is applied to a computer device, such as the computer device 1 shown in FIG. 10.

5 Depending on requirements, the order of steps in the flowchart may be changed, and some steps may be omitted.

[0032] S01: the computer device constructs a plane model of a concave and convex cam set based on structural data of a hinge.

[0033] In this embodiment of the present disclosure, a hinge applied in a foldable electronic
10 device includes a concave and convex cam set and a spring. The concave and convex cam set includes a first concave and convex cam and a second concave and convex cam that rotate in cooperation with each other. The first concave and convex cam and the second concave and convex cam are coaxially arranged, and a concave profile of the first concave and convex cam and a convex profile of the second concave and convex cam directly contact each other and may
15 mesh with each other during relative rotation. The spring is arranged along the hinge axis direction, and two ends of the spring respectively abut against the first concave and convex cam and the second concave and convex cam (or their respective connecting structures). The spring is in a compressed state, thereby continuously applying axial pressure to the first concave and convex cam and the second concave and convex cam, forcing the concave profile and the convex

profile always maintain tight pressed contact.

[0034] In this embodiment of the present disclosure, when designing the concave and convex cam set, the plane model may be constructed based on the structural data of the hinge.

The concave and convex cam set in the hinge structure include the first concave and convex cam

5 and the second concave and convex cam. The plane model includes a first model that represents a first profile of the first concave and convex cam, a second model that represents a second profile of the second concave and convex cam, and mechanical parameters of the hinge. The mechanical parameters include parameters corresponding to the spring in the hinge and a friction coefficient. The parameters corresponding to the spring include a number of springs, a stiffness
10 of the spring, and a preload of the spring.

[0035] In this embodiment of the present disclosure, constructing the plane model includes: constructing the first model by dividing the first profile into alternately distributed first linear segments and first curved segments; constructing the second model by dividing the second profile into alternately distributed second linear segments and second curved segments.

15 **[0036]** In this embodiment of the present disclosure, during a planar design process of the concave and convex cam, the first model and the second model may be described based on the planar design point coordinates of the concave and convex cam. For example, as shown in FIG. 2, taking a first starting point A of the first straight linear segment in the first profile as a first origin A, a line parallel to the horizontal line as a first X-axis, and a line perpendicular to the first

X-axis as a first Y-axis to establish a first coordinate system, where a plurality of first coordinate points are located in the first coordinate system. Taking a second starting point A' of the second straight linear segment in the second profile as a second origin A', a line parallel to the horizontal line as a second X-axis, and a line perpendicular to the second X-axis as a second Y-axis to
5 establish a second coordinate system. The positive direction of the first X-axis is opposite to the positive direction of the second X-axis, and the positive direction of the first Y-axis is opposite to the positive direction of the second Y-axis.

[0037] In the first coordinate system, take seven points on the first profile, respectively A, B, C, D, E, and F. Then, the first linear segments on the first profile include L_{AB} , L_{CD} and L_{EF} ,
10 and the first curved segments include R_{BC} and R_{DE} . The first linear segments and the first curved segments are arranged alternately. As shown in FIG. 2, the first model is obtained based on the first straight linear segment L_{AB} , the first arc segment R_{BC} , the first straight linear segment L_{CD} , the first arc segment R_{DE} , and the first straight linear segment L_{EF} .

[0038] In the second coordinate system, take seven points on the second profile, respectively
15 A', B', C', D', E', and F'. Then, the second linear segments on the second profile include $L_{A'B'}$, $L_{C'D'}$, and $L_{E'F'}$, and the second curved segments include $R_{B'C'}$ and $R_{D'E'}$. The second linear segments and the second curved segments are arranged alternately. As shown in FIG. 2, the second model is obtained based on the second straight linear segment $L_{A'B'}$, the second arc segment $R_{B'C'}$, the second straight linear segment $L_{C'D'}$, the second arc segment $R_{D'E'}$, and the

second straight linear segment $L_{E'F'}$.

[0039] S02: the computer device determines a plurality of meshing positions of the first model and the second model to construct a meshing point set.

[0040] In this embodiment of the present disclosure, the meshing positions of the first

5 concave and convex cam and the second concave and convex cam determine a hinge rotation angle corresponding to different torques, affecting the accuracy of the torque-rotation angle curve characterizing the hinge's torque performance. The meshing positions are determined based on the first concave and convex cam and the second concave and convex cam during the rotation process of the hinge. Specifically, during the rotation process of the hinge, the first

10 concave and convex cam and the second concave and convex cam mesh with each other. The meshing point set may be constructed according to the meshing positions of the first concave and convex cam and the second concave and convex cam during the rotation process of the hinge. Since there will be multiple meshing points between the first model corresponding to the first concave and convex cam and the second model corresponding to the second concave and convex

15 cam during the meshing process. In response that a slope corresponding to each meshing point on the first model is equal to a slope corresponding to each meshing point on the second model, then the meshing positions during the rotation process of the hinge may be determined according to the contour line slopes of the first model and the second model. The meshing point set is constructed by setting points on the first model at the meshing positions as the meshing points,

or setting points on the second model at the meshing positions as the meshing points.

[0041] In this embodiment of the present disclosure, both the first model and the second model include the linear segments and the curved segments. On a straight linear segment, the contour line slope is equal to a slope of the straight linear segment. On an arc segment, the contour line slope is equal to a slope of a tangent line at a certain point on the arc segment. Of course, besides using the contour line slope to determine the meshing positions of the first model and the second model during the rotation process of the hinge, other methods such as digital/physical model simulation or expert experience determination may also be used to determine the meshing positions, which will not be elaborated here.

[0042] For example, according to the contour line slopes of the first model and the second model, twenty meshing positions are determined during the rotation process of the hinge. These twenty meshing positions correspond to twenty meshing points on the first model and also correspond to twenty meshing points on the second model. The meshing point set may be constructed based on the twenty meshing points on the first model, or based on the twenty meshing points on the second model.

[0043] In this embodiment of the present disclosure, in response that the first concave and convex cam and the second concave and convex cam mesh. For example, as shown in FIG. 3, the meshing points on the first model and the second model are located on the first arc segment R_{BC} and the second arc segment $R_{B'C'}$. Then, a first tangent line of the first arc segment R_{BC} at

the meshing point coincides with a second tangent line of the second arc segment $R_{B'C'}$ at the meshing point, as shown in FIG. 4. The point where the first tangent line touches the first arc segment R_{BC} and the point where the second tangent line touches the second arc segment $R_{B'C'}$ corresponds to the meshing position. An angle between the first tangent line and the horizontal line is a slope angle, and an angle between the second tangent line and the horizontal line is also the slope angle. The angle between the second tangent line and the horizontal line is equal to the angle between the first tangent line and the horizontal line.

[0044] In this embodiment of the present disclosure, during the rotation process of the hinge, in response that the first concave and convex cam and the second concave and convex cam mesh, the slope at the meshing point is monotonically decreasing. Then, there are a pair of points with the same slope on each arc segment of the first model and each arc segment of the second model. For example, there are a pair of points with the same slope on the first arc segment R_{BC} and the second arc segment $R_{B'C'}$, and there are also a pair of points with the same slope on the first arc segment R_{DE} and the second arc segment $R_{D'E'}$.

[0045] In some embodiments of the present disclosure, the detailed steps for determining the meshing positions during the rotation process of the hinge according to the contour line slopes of the first model and the second model may be referred to the description of FIG. 5 below.

[0046] S03: the computer device determines a correspondence relationship between a torque and a hinge rotation angle at a meshing point of the meshing point set based on the mechanical

parameters of the hinge, and determines torque performance of the hinge based on the correspondence relationship.

[0047] In this embodiment of the present disclosure, after constructing the meshing point set, it is necessary to generate the torque-rotation angle curve of the hinge based on the torque and rotation angle corresponding to each meshing point, and use this curve to characterize the torque performance of the hinge. The correspondence relationship between torque at the meshing points in the meshing point set and the hinge rotation angle may be acquired to characterize the torque performance of the hinge.

[0048] During the rotation process of the hinge, the hinge rotation angle gradually changes, the meshing points also change accordingly, and the slope angle corresponding to the meshing point also changes. The correspondence relationship between torque at the meshing points in the meshing point set and the hinge rotation angle may be determined based on the mechanical parameters of the hinge. The torque of the hinge at the meshing point is calculated based on the spring force corresponding to the meshing point, the friction coefficient between the first concave and convex cam and the second concave and convex cam, and the slope angle of the first concave and convex cam and the second concave and convex cam at the meshing point, and the correspondence relationship between torque and hinge rotation angle is constructed. Specifically, acquiring the correspondence relationship between torque at the meshing points in the meshing point set and the hinge rotation angle includes: acquiring the hinge rotation angle at

the meshing point, the spring force at the meshing point, the friction coefficient between the first concave and convex cam and the second concave and convex cam, and the slope angle of the first concave and convex cam and the second concave and convex cam at the meshing point; acquiring the torque at the meshing point according to the hinge rotation angle, the spring force, the friction coefficient, and the slope angle, to construct the correspondence relationship between the torque and the hinge rotation angle.

[0049] In this embodiment of the present disclosure, the torque T of the hinge may be calculated by formula (1):

$$[0050] \quad T = F_T \times r_m \quad (1),$$

[0051] where F_T is an applied force corresponding to a preset value of the hinge rotation angle, and r_m is an average radius of the first concave and convex cam or the second concave and convex cam. For example, the average radius between an inner diameter and an outer diameter of the first concave and convex cam, or the average radius between the inner diameter and outer diameter of the second concave and convex cam.

[0052] According to the mechanical analysis when the hinge rotates to a preset rotation angle, the friction force F_u between the first concave and convex cam and the second concave and convex cam may be calculated by formula (2):

$$[0053] \quad F_u = \mu \times F_C = \mu \times (F_S \cos \alpha + F_T \sin \alpha) \quad (2),$$

[0054] where F_C is a vertical force corresponding to when the hinge rotates to the preset

rotation angle, F_S is a component force of F_C in the vertical direction, and F_T is the component force of F_C in the horizontal direction, as shown in FIG. 6. Then, when the hinge rotates along a first direction to the preset rotation angle, since the first cam and the second cam are in a static state at this time, the forces applied to the first concave and convex cam and the second concave and convex cam are balanced in the first direction, which may be expressed by formula (3); when the hinge rotates along a second direction to the preset rotation angle, the forces applied to the first concave and convex cam and the second concave and convex cam are balanced in the second direction, which may be expressed by formula (4);

[0055] $-F_u + F_T \cos \alpha = F_S \sin \alpha \quad (3),$

10 [0056] $F_u + F_T \cos \alpha = F_S \sin \alpha \quad (4),$

[0057] From the above formulas (3) and (4), the torque F_{T1} for the hinge rotating along the first direction and the torque F_{T2} for rotating along the second direction may be obtained respectively.

[0058] $F_{T1} = \frac{F_S(\sin \alpha + \mu \cos \alpha)}{\cos \alpha - \mu \sin \alpha} \quad (5),$

15 [0059] $F_{T2} = \frac{F_S(\sin \alpha - \mu \cos \alpha)}{\cos \alpha + \mu \sin \alpha} \quad (6),$

[0060] As shown in FIG. 5, it is a detailed flowchart for determining meshing positions during the rotation process of the hinge in the method for predicting hinge torque performance provided by an embodiment of the present disclosure. Depending on requirements, the order of

the steps in this detailed flowchart may be changed, and some steps can be omitted.

[0061] S51: the computer device determines a first reference point and a second reference point by acquiring a slope of a point on the first model and the second model.

[0062] In this embodiment of the present disclosure, as shown in FIG. 2, the first model
5 includes a first straight linear segment L_{AB} , a first arc segment R_{BC} , a first straight linear segment L_{CD} , a first arc segment R_{DE} , and a first straight linear segment L_{EF} . The second model includes a second straight linear segment $L_{A'B'}$, a second arc segment $R_{B'C'}$, a second straight linear segment $L_{C'D'}$, a second arc segment $R_{D'E'}$, and a second straight linear segment $L_{E'F'}$. During the rotation process of the hinge, the computer device determines the meshing positions of the
10 first model and the second model by determining the meshing point on the first straight linear segment L_{AB} and the second straight linear segment $L_{A'B'}$, then determining the meshing point on the first arc segment R_{BC} and the second arc segment $R_{B'C'}$, and determining the meshing point on the first straight linear segment L_{CD} and the second straight linear segment $L_{C'D'}$, and determining the meshing point on the first arc segment R_{DE} and the second arc segment $R_{D'E'}$,
15 and determining the meshing point on the first straight linear segment L_{EF} and the second straight linear segment $L_{E'F'}$. Since the slope of a straight linear segment is unique, the meshing point between a straight linear segment on the first model and the corresponding straight linear segment on the second model may be determined according to the slope of the straight linear segment on the first model and the slope of the straight linear segment on the second model.

However, since the slope of an arc segment changes with the points on the arc segment, the meshing positions during the hinge rotation process may be determined according to the slopes of the curved segments.

[0063] In this embodiment of the present disclosure, the detailed flowchart for determining

5 meshing positions during the rotation process shown in FIG. 5, may be used to determine the meshing positions on the first arc segment R_{BC} and the second arc segment $R_{B'C'}$, and may also be used to determine the meshing positions on the first arc segment R_{DE} and the second arc segment $R_{D'E'}$. The present disclosure uses the first arc segment R_{BC} and the second arc segment $R_{B'C'}$ for explanation. The computer device acquires the slopes of points on the first arc segment R_{BC} of the first model and acquires the slopes of points on the second arc segment $R_{B'C'}$ of the
10 second model and determines a first reference point and a second reference point. The first reference point may be an intersection point of the first straight linear segment L_{AB} and the first arc segment R_{BC} , such as point Y in FIG. 2. The second reference point may be an intersection point of the second straight linear segment $L_{A'B'}$ and the second arc segment $R_{B'C'}$, such as point
15 Y' in FIG. 2. The slope of the first model at the first reference point is equal to the slope of the second model at the second reference point.

[0064] S52: the computer device selects a first target point on the first model along the rotation direction of the hinge, and selects a second target point on the second model along the rotation direction of the hinge.

[0065] In some embodiments of the present disclosure, during the rotation process, the computer device determines the meshing positions on the first arc segment R_{DE} and the second arc segment $R_{D'E'}$. A first target point may be selected on the first model, and a second target point may be selected on the second model.

5 **[0066]** S53: the computer device determines a first slope of a line from the first reference point to the first target point and a second slope of a line from the second reference point to the second target point.

[0067] In this embodiment of the present disclosure, the computer device determines the first slope based on a linear segment between the first reference point and the first target point,
10 and determines the second slope based on a linear segment between the second reference point and the second target point.

[0068] S54: the computer device compares the first slope with the second slope. In response that the first slope is greater than the second slope, the process proceeds to step S55; in response that the first slope equals the second slope, the process proceeds to step S56; in response that the
15 first slope is less than the second slope, the process proceeds to step S57.

[0069] In this embodiment of the present disclosure, the computer device determines whether the meshing point is found based on the first slope and the second slope. In response that the first slope is different from the second slope, it is necessary to traverse the first model or the second model until the meshing point is found, making the first slope and the second slope

equal. In response that the first slope is the same as the second slope, it is determined that the meshing point is found. Specifically, in response that the first slope is greater than the second slope, it is determined that the meshing point has not been found yet, and the process proceeds to step S55; in response that the first slope is equal to the second slope, it is determined that the meshing point is found, and the process proceeds to step S56; in response that the first slope is less than the second slope, it is determined that the meshing point has not been found yet, and the process proceeds to step S57.

[0070] S55: In response that the first slope is greater than the second slope, the computer device sets the first model as a meshing search area, and reselects the first target point on the first model along the rotation direction of the hinge to make the first slope equal the second slope.

[0071] In this embodiment, in response that the first slope is greater than the second slope, it is determined that the meshing point has not been found yet. The computer device sets the first model as the meshing search area, and reselects the first target point on the first model along the rotation direction of the hinge to make the first slope equal the second slope.

[0072] In some embodiments of the present disclosure, the computer device reselects the first target point on the first model along the rotation direction of the hinge by reselecting the first target point on the first model based on a binary interpolation method to make the first slope equal the second slope. The detailed steps for reselecting the first target point on the first model to make the first slope and the second slope equal may be referred to the description of FIG. 8

below.

[0073] S56: In response that the first slope is equal to the second slope, the computer device sets a location of the first target point or the second target point as the meshing position.

[0074] In this embodiment, in response that the first slope is equal to the second slope, it is
5 determined that the meshing point is found. The computer device sets the location of the first target point or the second target point as the meshing position.

[0075] S57: In response that the first slope is less than the second slope, the computer device sets the second model as the meshing search area, and reselects the second target point on the second model along the rotation direction of the hinge to make the first slope equal the second
10 slope.

[0076] In this embodiment of the present disclosure, in response that the first slope is less than the second slope, it is determined that the meshing point has not been found yet. The computer device sets the second model as the meshing search area, and reselects the second target point on the second model along the rotation direction of the hinge to make the first slope
15 equal the second slope.

[0077] In some embodiments of the present disclosure, the computer device reselects the second target point on the second model along the rotation direction of the hinge by reselecting the second target point on the second model based on a binary interpolation method to make the first slope equal the second slope. The detailed steps for reselecting the second target point on

the second model to make the first slope and the second slope equal can be referred to the description of FIG. 9 below.

[0078] As shown in FIG. 8, it is a detailed flowchart for reselecting the first target point on the first model in the method for predicting hinge torque performance provided by an embodiment of the present disclosure. Depending on requirements, the order of the steps in this detailed flowchart may be changed, and some steps may be omitted.

[0079] Step 11: the computer device selects a third reference point behind the first target point along the rotation direction of the hinge.

[0080] In this embodiment of the present disclosure, in response that the first slope is greater than the second slope, it is determined that the meshing point has not been found yet. The computer device sets the first model as the meshing search area, and searches for the meshing point on the first model and selects a third reference point behind the first target point.

[0081] Step 12: The computer device sets a midpoint of a linear segment between the first reference point and the first target point as a first midpoint, sets a midpoint of a linear segment between the first target point and the third reference point as a second midpoint, determines a third slope of a linear segment between the first midpoint and the second midpoint, and compares the third slope with the second slope.

[0082] In this embodiment of the present disclosure, the computer device sets the first model as the meshing search area and the second model as a reference area. The computer device selects

the first reference point behind the first target point on the first model and determines the first linear segment between the first reference point and the first target point, and obtains the first midpoint of the first linear segment based on the first reference point and the first target point. The computer device determines the second linear segment between the first target point and the third reference point, and obtains the second midpoint of the second linear segment based on the first target point and the third reference point. The computer device obtains a third linear segment based on the first midpoint and the second midpoint, and determines the third slope of the third linear segment, and compares the third slope with the second slope.

[0083] Step 13: In response that the third slope is equal to the second slope, the computer device updates the third reference point to be the first target point.

[0084] In this embodiment of the present disclosure, in response that the third slope is equal to the second slope, it is determined that the third reference point is located at a top of the first arc segment of the first model, and updates the third reference point to be the first target point.

[0085] Step 14: In response that the third slope is greater than the second slope, the computer device updates the first midpoint to be the first reference point, and updates the second midpoint to be the first target point, and return to Step 12.

[0086] In this embodiment of the present disclosure, in response that the third slope is greater than the second slope, it is necessary to continue searching for a point that may make the third slope equal to the second slope. Then the computer device updates the first midpoint to be

the first reference point, and updates the second midpoint to be the first target point, and returns to Step 12 to continue calculating the third slope and comparing it with the second slope.

[0087] Step 15: In response that the third slope is less than the second slope, the computer device updates the first midpoint to be the first target point, and updates the second midpoint to be the third reference point, and returns to Step 12.

[0088] In this embodiment of the present disclosure, in response that the third slope is less than the second slope, it is necessary to continue searching for a point that may make the third slope equal to the second slope. The computer device updates the first midpoint to be the first target point, and updates the second midpoint to be the third reference point, and returns to Step 12 to continue calculating the third slope and comparing it with the second slope.

[0089] In this embodiment of the present disclosure, as shown in FIG. 8, the computer device sets the first model as the meshing search area and the second model as the reference area. the computer device sets point P0 in the first model as the first reference point, point P1 as the first target point, and selects a third reference point P2 behind the first target point P1. The computer device sets the midpoint of the linear segment between the first reference point P0 and the first target point P1 as the first midpoint PM1, sets the midpoint of the linear segment between the first target point P1 and the third reference point P2 as the second midpoint PM2, determines the third slope of the linear segment from the first midpoint PM1 to the second midpoint PM2, and compares the third slope with the second slope. In response that the third slope is equal to

the second slope, the computer device updates the third reference point to be the first target point.

In response that the third slope is greater than the second slope, the computer device updates the first midpoint PM1 to be the first reference point P0, and updates the second midpoint to be the first target point P1, then returns to Step S12, and so on, until the third slope equals the second

5 slope. In response that the third slope is less than the second slope, the computer device updates the first midpoint PM1 to be the first target point P1, and updates the second midpoint PM2 to be the third reference point P2, then returns to Step S12, and so on, until the third slope equals the second slope.

[0090] As shown in FIG. 9, it is a detailed flowchart for reselecting the second target point

10 on the second model in the method for predicting hinge torque performance provided by an embodiment of the present disclosure. Depending on requirements, the order of the steps in this detailed flowchart may be changed, and some steps may be omitted.

[0091] Step 21: the computer device selects a fourth reference point behind the second target point along the rotation direction of the hinge.

15 **[0092]** In this embodiment of the present disclosure, in response that the first slope is less than the second slope, it is determined that the meshing point has not been found yet. The computer device sets the second model as the meshing search area, searches for the meshing point on the second model, and selects a fourth reference point behind the second target point.

[0093] Step 22: the computer device sets the midpoint of the linear segment between the

second reference point and the second target point as a third midpoint, sets the midpoint of the linear segment between the second target point and the fourth reference point as a fourth midpoint, and compares a fourth slope of a line between the third midpoint and the fourth midpoint with the first slope.

5 **[0094]** In this embodiment of the present disclosure, the computer device sets the second model as the meshing search area and the first model as the reference area. The computer device selects the fourth reference point behind the second target point on the second model, determines the fourth linear segment between the fourth reference point and the second target point, and obtains the third midpoint of a fourth linear segment based on the fourth reference point and the
10 second target point. Then the computer device determines the fifth linear segment between the second target point and the fourth reference point, and obtains the fourth midpoint of a fifth linear segment based on the second target point and the fourth reference point. The computer device obtains a sixth linear segment based on the third midpoint and the fourth midpoint, determines a fourth slope of this sixth linear segment, and compares the fourth slope with the first slope.

15 **[0095]** Step 23: In response that the fourth slope is equal to the first slope, the computer device updates the fourth reference point to be the second target point.

[0096] In this embodiment of the present disclosure, in response that the fourth slope is equal to the first slope, it is determined that the fourth reference point is located at a top of the second arc segment of the second model, and updates the fourth reference point to be the second

target point.

[0097] Step 24: In response that the fourth slope is greater than the first slope, the computer device updates the third midpoint to be the second reference point, and updates the fourth midpoint to be the second target point, and returns to Step 22.

5 **[0098]** In this embodiment of the present disclosure, in response that the fourth slope is greater than the first slope, it is necessary to continue searching for a point that may make the fourth slope equal to the first slope. Then the computer device updates the third midpoint to be the second reference point, and updates the fourth midpoint to be the second target point, and returns to Step 22 to continue calculating the fourth slope and comparing it with the first slope.

10 **[0099]** Step 25: In response that the fourth slope is less than the first slope, the computer device updates the third midpoint to be the second target point, and updates the fourth midpoint to be the fourth reference point, and returns to Step 22.

[00100] In this embodiment of the present disclosure, in response that the fourth slope is less than the first slope, it is necessary to continue searching for a point that may make the fourth
15 slope equal to the first slope. The computer device updates the third midpoint to be the second target point, updates the fourth midpoint to be the fourth reference point, and returns to Step 12 to continue calculating the fourth slope and comparing it with the first slope.

[00101] As shown in FIG. 10, it is a functional block diagram of an apparatus for acquiring hinge torque performance provided by an embodiment of the present disclosure. The apparatus

10 for acquiring hinge torque performance runs on the computer device 1. The apparatus 10 for acquiring hinge torque performance includes a processing module 101, a determining module 102, and an acquiring module 103. The modules/units referred to in the present disclosure refer to a series of computer-readable instruction segments that can be acquired by a processor and
5 can complete fixed functions, stored in a storage device.

[00102] The processing module 101 is configured to construct a plane model of a concave and convex cam set based on structural data of a hinge, wherein the plane model comprises a first model that represents a first profile of a first concave and convex cam of the concave and convex cam set, a second model that represents a second profile of a second concave and convex
10 cam of the concave and convex cam set, and mechanical parameters of the hinge; the determining module 102 is configured to determine a plurality of meshing positions of the first model and the second model to construct a meshing point set, wherein the meshing positions are determined based on the first concave and convex cam and the second concave and convex cam during a rotation process of the hinge; the acquiring module 103 is configured to determine a
15 correspondence relationship between a torque and a hinge rotation angle at a meshing point of the meshing point set based on the mechanical parameters of the hinge, and determines torque performance of the hinge based on the correspondence relationship.

[00103] In some embodiments of the present disclosure, the processing module 101 is further configured to: the first profile into alternately distributed first linear segments and first curved

segments to construct the first model; divide the second profile into alternately distributed second linear segments and second curved segments.

[00104] In some embodiments of the present disclosure, the processing module 101 is further configured to: determine the meshing positions during the rotation process of the hinge according to contour line slopes of the first model and the second model; and set points on the first model at the meshing positions as the meshing points to construct the meshing point set, or set points on the second model at the meshing positions as the meshing points to construct the meshing point set.

[00105] In some embodiments of the present disclosure, the processing module 101 is further configured to: determine a first reference point and a second reference point by acquiring a slope of a point on the first model and the second model; select a first target point on the first model along the rotation direction of the hinge, and select a second target point on the second model along the rotation direction of the hinge; in response that a first slope of a line from the first reference point to the first target point is equal to a second slope of a line from the second reference point to the second target point, set a location of the first target point or the second target point as the meshing position; in response that the first slope is greater than the second slope, setting the first model as a meshing search area, and reselect the first target point on the first model along the rotation direction of the hinge to make the first slope equal the second slope; in response that the first slope is less than the second slope, set the second model as the meshing

search area, and reselect the second target point on the second model along the rotation direction of the hinge to make the first slope equal the second slope.

[00106] In some embodiments of the present disclosure, the processing module 101 is further configured to: reselect the first target point on the first model based on a binary interpolation
5 method to make the first slope equal the second slope; and reselect the second target point on the second model through the binary interpolation method to make the first slope equal the second slope.

[00107] In some embodiments of the present disclosure, the processing module 101 is further configured to: select a third reference point behind the first target point along the rotation
10 direction of the hinge; set a midpoint of a linear segment between the first reference point and the first target point as a first midpoint, set a midpoint of a linear segment between the first target point and the third reference point as a second midpoint, determining a third slope of a linear segment between the first midpoint and the second midpoint, and comparing the third slope with the second slope; in response that the third slope is equal to the second slope, update the third
15 reference point to be the first target point; in response that the third slope is greater than the second slope, update the first midpoint to be the first reference point, and update the second midpoint to be the first target point; in response that the third slope is less than the second slope, update the first midpoint to be the first target point, and update the second midpoint to be the third reference point.

[00108] In some embodiments of the present disclosure, the processing module 101 is further configured to: select a fourth reference point behind the second target point along the rotation direction of the hinge; set the midpoint of the linear segment between the second reference point and the second target point as a third midpoint, set the midpoint of the linear segment between the second target point and the fourth reference point as a fourth midpoint, and compare a fourth slope of a line between the third midpoint and the fourth midpoint with the first slope; in response that the fourth slope is equal to the first slope, update the fourth reference point to be the second target point; in response that the fourth slope is greater than the first slope, update the third midpoint to be the second reference point, and update the fourth midpoint to be the second target point.

[00109] FIG. 11 is a structural schematic diagram of a computer device provided by an embodiment of the present disclosure. As shown, the computer device 1 may be a server, such as a central server, edge server, or a local server in a local data center. Each computer device 1 may include a communication module 101, a storage device 102, a processor 103, an input/output (I/O) interface 104, and a bus 105. The processor 103 is coupled to the communication interface 101, the storage device 102, and the I/O interface 104 via the bus 105.

[00110] The communication module 101 may include a wired communication module and/or a wireless communication module. The wired communication module may provide one or more solutions such as Universal Serial Bus (USB), Controller Area Network (CAN), etc. The

wireless communication module may provide one or more wireless communication solutions such as Wireless Fidelity (Wi-Fi), Bluetooth (BT), mobile communication network, Frequency Modulation (FM), Near Field Communication (NFC), Infrared (IR), etc.

[00111] The storage device 102 may include one or more Random Access Memories (RAM)

5 and one or more Non-Volatile Memories (NVM). RAM can be directly read and written by the processor 103 and is used to store executable programs for the operating system or other running programs (e.g., machine instructions) and may also be used to store user and application data. RAM may include Static RAM (SRAM), Dynamic RAM (DRAM), Synchronous DRAM (SDRAM), Double Data Rate SDRAM (DDR SDRAM), etc.

10 **[00112]** The NVM may also store executable programs and user/application data, may be loaded into RAM in advance for direct reading and writing by the processor 103. The NVM may include a disk storage device, or a flash memory.

[00113] The storage device 102 is used to store one or more computer programs. The one or more computer programs are configured to be executed by the processor 103. The one or more
15 computer programs include a plurality of instructions which, when executed by the processor 103, implement the method for predicting hinge torque performance executed on the computer device 1.

[00114] In other embodiments, the computer device 1 also includes an external memory interface for connecting external memory to expand the storage capacity of the computer device

1.

[00115] The processor 103 may include one or more processing units, for example, an Application Processor (AP), a modem processor, a Graphics Processing Unit (GPU), an Image Signal Processor (ISP), a controller, a video codec, a Digital Signal Processor (DSP), a baseband processor, and/or a Neural-Network Processing Unit (NPU). Different processing units may be independent devices or integrated into one or more processors.

[00116] The processor 103 provides computing and control capabilities, for example, the processor 103 is used to execute computer programs stored in the storage device 102.

[00117] The I/O interface 104 is used to provide channels for user input or output. For example, the I/O interface 104 may be used to connect various input/output devices, such as a mice, a keyboard, a touch device, a display, etc., allowing users to input information or visualize information.

[00118] The bus 105 is used to provide communication channels at least between the communication module 101, the storage device 102, the processor 103, and the I/O interface 104 within the computer device 1.

[00119] It is understandable that the structure shown in the embodiments of the present disclosure does not constitute a specific limitation on the computer device 1. In other embodiments of the present disclosure, the computer device 1 may include more or fewer components than shown, or combine certain components, or split certain components, or have

different component arrangements. The illustrated components may be implemented in hardware, software, or a combination of software and hardware.

[00120] Embodiments of the present disclosure also provide a computer-readable storage medium. The computer-readable storage medium stores a computer program. The computer
5 program includes program instructions. The method implemented when the program instructions are executed can refer to the methods in the various embodiments of the present disclosure described above.

[00121] The computer-readable storage medium may be the internal memory of the electronic device described in the above embodiments, such as the hard disk or memory of the
10 electronic device. The computer-readable storage medium may also be an external storage device of the electronic device, such as a plug-in hard disk equipped on the electronic device, a Smart Media Card (SMC), a Secure Digital (SD) card, a Flash Card, etc.

[00122] In some embodiments, the computer-readable storage medium may include a program storage area and a data storage area. The program storage area may store an operating
15 system, applications required for at least one function, etc. The data storage area may store data created according to the use of the electronic device, etc.

[00123] In the above embodiments, the descriptions of the various embodiments have their own emphasis. For parts not detailed or recorded in a certain embodiment, refer to the relevant descriptions in other embodiments.

[00124] Those of ordinary skill in the art can appreciate that the units and algorithm steps described in the examples combined with the embodiments disclosed herein can be implemented in electronic hardware, or a combination of computer software and electronic hardware. Whether these functions are performed by hardware or software depends on the specific application and design constraints of the technical solution. Professionals can use different methods for each specific application to implement the described functions, but such implementation should not be considered beyond the scope of the present disclosure.

[00125] In the embodiments provided in the present disclosure, it should be understood that the disclosed apparatus/terminal device and method may be implemented in other ways. For example, the apparatus/terminal device embodiments described above are merely illustrative. For instance, the division of modules or units is only a logical functional division. In actual implementation, there may be other division methods, for example, multiple units or components may be combined or integrated into another system, or some features may be ignored or not executed. Additionally, the displayed or discussed mutual couplings or direct couplings or communication connections may be indirect couplings or communication connections through some interfaces, devices, or units, which may be electrical, mechanical, or other forms.

[00126] The units described as separate components may or may not be physically separate. Components displayed as units may or may not be physical units; they may be located in one place or distributed across multiple network units. Some or all of the units may be selected

according to actual needs to achieve the objectives of the solutions of the embodiments.

[00127] The above-described embodiments are only used to illustrate the technical solutions of the present disclosure and are not intended to limit them. Although the present disclosure has been described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that they may still modify the technical solutions described in the foregoing embodiments or equivalently replace some of the technical features. However, these modifications or replacements do not cause the essence of the corresponding technical solutions to deviate from the spirit and scope of the technical solutions of the embodiments of the present disclosure, and should be included within the protection scope of the present disclosure.

[00128] The above description is only a partial implementation method of the present disclosure. It should be pointed out that for ordinary technicians in this technical field, several improvements and modifications may be made without departing from the principles of the present disclosure. These improvements and modifications should also be regarded as the scope of protection of the present disclosure.

CLAIMS

What is claimed is:

1. A method for predicting hinge torque performance, comprising:

constructing a plane model of a concave and convex cam set based on structural data of a
5 hinge, wherein the plane model comprises a first model that represents a first profile of a first
concave and convex cam of the concave and convex cam set, a second model that represents a
second profile of a second concave and convex cam of the concave and convex cam set, and
mechanical parameters of the hinge;

determining a plurality of meshing positions of the first model and the second model, and
10 constructing a meshing point set, wherein the meshing positions are determined based on the
first concave and convex cam and the second concave and convex cam during a rotation process
of the hinge;

determining a correspondence relationship between a torque and a hinge rotation angle at a
meshing point of the meshing point set based on the mechanical parameters of the hinge, and
15 determining torque performance of the hinge based on the correspondence relationship.

2. The method according to claim 1, wherein the constructing the plane model of the
concave and convex cam set comprises:

constructing the first model by dividing the first profile into alternately distributed first
linear segments and first curved segments;

constructing the second model by dividing the second profile into alternately distributed second linear segments and second curved segments.

3. The method according to claim 2, wherein the determining the plurality of meshing positions of the first model and the second model to construct the meshing point set comprises:

5 determining the meshing positions during the rotation process of the hinge according to contour line slopes of the first model and the second model; and

setting points on the first model at the meshing positions as the meshing points to construct the meshing point set, or setting points on the second model at the meshing positions as the meshing points to construct the meshing point set.

10 4. The method according to claim 3, wherein the determining the meshing positions during the rotation process of the hinge according to contour line slopes of the first model and the second model comprises:

determining a first reference point and a second reference point by acquiring a slope of a point on the first model and the second model;

15 selecting a first target point on the first model along the rotation direction of the hinge, and selecting a second target point on the second model along the rotation direction of the hinge;

in response that a first slope of a line from the first reference point to the first target point is equal to a second slope of a line from the second reference point to the second target point, setting a location of the first target point or the second target point as the meshing position;

in response that the first slope is greater than the second slope, setting the first model as a meshing search area, and reselecting the first target point on the first model along the rotation direction of the hinge to make the first slope and the second slope equal;

5 in response that the first slope is less than the second slope, setting the second model as the meshing search area, and reselecting the second target point on the second model along the rotation direction of the hinge to make the first slope and the second slope equal.

5. The method according to claim 4, wherein the reselecting the first target point on the first model along the rotation direction of the hinge comprises:

10 reselecting the first target point on the first model through a binary interpolation method to make the first slope and the second slope equal;

wherein the reselecting the second target point on the second model along the rotation direction of the hinge comprises:

reselecting the second target point on the second model through the binary interpolation method to make the first slope and the second slope equal.

15 6. The method according to claim 5, wherein the reselecting the first target point on the first model through the binary interpolation method comprises:

Step 11, selecting a third reference point after the first target point along the rotation direction of the hinge;

Step 12: setting a midpoint of a linear segment between the first reference point and the first

target point as a first midpoint, setting a midpoint of a linear segment between the first target point and the third reference point as a second midpoint, determining a third slope of a linear segment between the first midpoint and the second midpoint, and comparing the third slope with the second slope;

5 Step 13: in response that the third slope is equal to the second slope, updating the third reference point to be the first target point;

Step 14: in response that the third slope is greater than the second slope, updating the first midpoint to be the first reference point, and updating the second midpoint to be the first target point, and returning to Step 12;

10 Step 15: in response that the third slope is less than the second slope, updating the first midpoint to be the first target point, and updating the second midpoint to be the third reference point, and returning to Step 12;

wherein the reselecting the second target point on the second model through the binary interpolation method comprises:

15 Step 21: selecting a fourth reference point after the second target point along the rotation direction of the hinge;

Step 22: setting the midpoint of the linear segment between the second reference point and the second target point as a third midpoint, setting the midpoint of the linear segment between the second target point and the fourth reference point as a fourth midpoint, and comparing a

fourth slope of a line between the third midpoint and the fourth midpoint with the first slope;

Step 23: in response that the fourth slope is equal to the first slope, updating the fourth reference point to be the second target point;

Step 24: in response that the fourth slope is greater than the first slope, updating the third
5 midpoint to be the second reference point, and updating the fourth midpoint to be the second target point, and returning to Step 22.

7. The method according to claim 1, wherein the determining a correspondence relationship between a torque and a hinge rotation angle at the meshing point of the meshing point set based on the mechanical parameters of the hinge comprises:

10 acquiring the hinge rotation angle at the meshing point, a spring force at the meshing point, a friction coefficient between the first concave and convex cam and the second concave and convex cam, and a slope angle of the first concave and convex cam and the second concave and convex cam at the meshing point;

constructing the correspondence relationship between the torque and the hinge rotation
15 angle by acquiring the torque at the meshing point according to the hinge rotation angle, the spring force, the friction coefficient, and the slope angle.

8. An apparatus for acquiring hinge torque performance, comprising:

a processing module, configured to construct a plane model of a concave and convex cam set based on structural data of a hinge, wherein the plane model comprises a first model that

represents a first profile of a first concave and convex cam of the concave and convex cam set,
a second model that represents a second profile of a second concave and convex cam of the
concave and convex cam set, and mechanical parameters of the hinge;

a determining module, configured to determine a plurality of meshing positions of the first
5 model and the second model to construct a meshing point set, wherein the meshing positions are
determined based on the first concave and convex cam and the second concave and convex cam
during a rotation process of the hinge;

an acquiring module, configured to determine a correspondence relationship between a
torque and a hinge rotation angle at a meshing point of the meshing point set based on the
10 mechanical parameters of the hinge, and determine torque performance of the hinge based on
the correspondence relationship.

9. A computer device comprising a storage device, at least one processor, and the storage
device storing one or more programs that, when executed by the at least one processor, cause the
at least one processor to execute a method according to any one of claims 1 to 7.

15 10. A non-transitory storage medium having instructions stored thereon, when the
instructions are executed by a processor of a computer device, the processor is caused to perform
a method according to any one of claims 1 to 7.