

ROBOTIC OBJECT MOVING SYSTEM AND METHOD FOR MOVING OBJECT WITH UNKNOWN WEIGHT DISTRIBUTION

FIELD OF THE INVENTION

[0001] The present disclosure relates to a robotic object moving system and a method for moving an object, and more particularly to a robotic object moving system and a method for moving an object with unknown weight distribution.

BACKGROUND OF THE INVENTION

[0002] In modern days, robotic systems are widely used for industrial applications due to their capability to handle missions difficult for human labors, such as manufacturing, logistics, etc. Such robotic systems may be a robot or a robot arm, and contributed to the fast development of relevant technologies, they can move autonomously without constant human intervention. For example, the robot arm system can be utilized to pick up boxes in factory areas or logistic sites, so as to move particles or goods from one place to another. Upon the robot arm system detects a box that needs to be picked up, the robot arm performs a picking task to pick up the box as programmed.

[0003] Conventionally, the robot arm system utilizes a camera to capture the photo of the box, then the robot arm system determines the picking position according to the information obtained through the photo. For example, the robot arm system determines the center of the box by the photo, and the robot arm picks up the box according to the position of the center of the surface area of the box. However, in reality, the robot arm system might need to handle various boxes with different sizes and different weights, and the weight distribution of the boxes cannot be determined from the photos captured by the camera. That would cause

problems of unstable movements while the boxes are picked up and moved through the air by the robot arm system. Goods and particles contained in the boxes may move their positions and hit with each other. Even worse, they might swing or be dropped off from the robot arm system, and lead to severe damages or losses. Since the sizes of different boxes may not be fixed and the weights of different boxes may not be uniform, the picking process with the same picking position at the centers of the boxes may not be a robust solution. Specifically, the boxes might be leaned or shaken due to unbalanced weight distribution of the boxes when they are picked up at the center positions of the boxes, consequently the boxes might be dropped and broken or harmed during the picking process. In addition, even if it is possible to pick up all boxes at the center positions, it may require large forces so as to avoid unstable incidents during the pickup process.

[0004] Therefore, there is a need of providing a robotic object moving system and a method for moving an object with unknown weight distribution to obviate the drawbacks encountered from the prior arts.

SUMMARY OF THE INVENTION

[0005] It is an object of the present disclosure to provide a robotic object moving system and a method for moving an object with unknown weight distribution. In the robotic object moving system of the present disclosure, the pickup position of the object is adjusted by use of the sensor data obtained during an initial pickup attempt. Therefore, the stability of picking objects with unfixed size and uneven weight is improved. In addition, compared to the conventional pickup solutions that utilize the center of the surface area of the object to be the pickup position, the object can be picked up first with a smaller picking force in the initial pickup attempt so as to adjust the pickup position according to the sensor data

obtained during the initial pickup attempt, which would be closer to the center of mass of the object.

[0006] In accordance with an aspect of the present disclosure, there is provided a method for moving an object with unknown weight distribution, including steps of: obtaining at least one image of the object placed at a starting location; processing the image to determine an available pickup area on a first surface of the object and a first position corresponding to a center of the available pickup area as a pickup position; picking up the object by a pickup module with a predetermined lifting distance for a first time period by applying a pickup force of a predetermined first level to the first surface at the pickup position; obtaining a sensor data in at least two dimensions corresponding to the pickup module during the first time period; determining whether to adjust the pickup position based on the sensor data by using a first pre-trained model in comply with a first criteria; adjusting the pickup position for obtaining an adjusted pickup position based on the sensor data and the available pickup area on the first surface of the object by using a second pre-trained model in comply with a second criteria; and picking up the object at the adjusted pickup position and moving the object from the starting location to a destination location.

[0007] In accordance with an aspect of the present disclosure, there is provided a robotic object moving system. The robotic object moving system includes an image retrieving module, an image processing module, a pickup module, a sensing module and a control module. The image retrieving module is configured for obtaining at least one image of an object placed at a starting location. The image processing module is connected to the image retrieving module, wherein the image processing module is configured for processing the at least one image to determine an available pickup area on a first surface of the object and a first position

corresponding to a center of the available pickup area as a pickup position. The pickup module is configured for picking up the object with a predetermined lifting distance for a first time period by applying a pickup force of a predetermined first level to the first surface at the pickup position. The sensing module is connected to the pickup module, wherein the sensing module is configured for sensing a sensor data in at least two dimensions corresponding to the pickup module during the first time period. The control module is connected to the image processing module, the pickup module and the sensing module, wherein the control module is configured for controlling the pickup module, and determining whether to adjust the pickup position based on the sensor data by using a first pre-trained model in comply with a first criteria, wherein the control module adjusts the pickup position for obtaining an adjusted pickup position based on the sensor data and the available pickup area on the first surface of the object by using a second pre-trained model in comply with a second criteria. The pickup module picks up the object at the adjusted pickup position and moves the object from the starting location to a destination location.

[0008] The above contents of the present invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic system diagram illustrating a robot arm system according to an embodiment of the present disclosure;

[0010] FIG. 2 is a schematic view illustrating the robotic object moving system of FIG. 1;

[0011] FIG. 3 is a top view of the object 7 where there is a distance between the pickup position A and the adjusted pickup position B;

[0012] FIG. 4A is a distributed schematic diagram illustrating the torque value and the force value sensed by the sensing module 5, and FIG. 4B is a distributed schematic diagram illustrating the torque value and the force value separated as three regions by the thresholds;

[0013] FIG. 5 is a schematic flow chart illustrating a method for moving an object with unknown weight distribution according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] The present disclosure will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this disclosure are presented herein for the purposes of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

[0015] FIG. 1 is a schematic system diagram illustrating a robotic object moving system 1 according to an embodiment of the present disclosure. FIG. 2 is a schematic view illustrating the robotic object moving system 1 of FIG. 1. FIG. 3 is a top view of the object 7 where there is a distance between the pickup position A and the adjusted pickup position B. As shown in FIGs. 1, 2 and 3, the robotic object moving system 1 includes an image retrieving module 2, an image processing module 3, a pickup module 4, a sensing module 5 and a control module 6. In embodiments of the present disclosure, the robotic object moving system 1 may perform object pickup in an initial pickup attempt at an initial pickup position, determine weight distribution information of the object 7 according to sensor data obtained by the sensing module 5, and adjust to an optimized pickup position according to the weight distribution information from the control module 6, eventually perform the pickup task at the

adjusted pickup position. In addition to the pickup position, the sensor data obtained by the sensing module 5 can also be utilized to adjust the pickup force.

[0016] The image retrieving module 2 is configured for obtaining at least one image of an object 7 placed at a starting location. In an embodiment of the present disclosure, a camera is connected to the image retrieving module 2, and the camera is configured for generating and providing one or more images to the image retrieving module 2. The camera can be externally connected to the robotic object moving system 1. The image retrieving module 2 can be a wired or wireless communication interface. For example, the image retrieving module 2 can be a wireless communication interface using IrDA, Bluetooth, Wi-Fi, cellular or any suitable wireless communication protocol. The external camera may transmit the image(s) of the object 7 wirelessly to the image retrieving module 2. Alternatively, in another embodiment of the present disclosure, the camera can be part of the image retrieving module 2, and be internal to the robotic object moving system 1.

[0017] The image processing module 3 is connected to the image retrieving module 2 and is configured for processing the at least one image to determine an available pickup area on a first surface of the object 7 and a first position corresponding to a center of the available pickup area as a pickup position. The image processing module 3 may utilize image processing techniques known by one with skills in the art to obtain information of the object 7, such as object detection, edge detection, etc., which are readily known and will not be repeated here. In an embodiment, the available pickup area is a square area or a circular area with edges not exceeding outer edges of the object 7. The initial pickup position based on the center of the available pickup area is referred to point “A” shown in

FIG. 3 as an example, and the available pickup area of the object 7 is referred to dashed rectangle shown in FIG. 3. In embodiments of the present disclosure, the image processing module 3 can be a separate module to the image retrieving module 2, or can be integrated with the image retrieving module 2. For example, the image processing module 3 can be a dedicated image signal processor, or as part of a graphic processor or a general-purpose processor. Yet in another example, the image retrieving module 2 and the image processing module 3 can be implemented together in an image unit of the robotic object moving system 1.

[0018] The pickup module 4 is configured for picking up the object 7 and is connected to the sensor module 5 and control module 6. The pickup module 4 may perform the object pickup according to control instructions/signals/commands from the control module 6. In an embodiment of the present disclosure, the pickup module 4 may perform a first pickup attempt to pick up the object 7 with a predetermined lifting distance for a first time period by applying a pickup force of a predetermined first level to the first surface at an initial pickup position so as to determine the weight distribution of the object 7, and perform the pickup task at an adjusted pickup position determined according to the sensor data obtained in the first pickup attempt so as to move the object 7 from a starting location to a destination location. The control mechanism of the control module 6 and the pickup module 4 will be described in detail later in below.

[0019] In embodiments of the present disclosure, the pickup module 4 includes a pickup unit having single point or area of contact with the object 7, and the contact area is comparatively much smaller than the object 7. In the case that the contact area of the pickup unit and the object 7 is

equivalent or very close, unbalanced weight distribution would not be an issue for the robotic object moving system since the force can be evenly applied to large portion of the surface area of the object 7. However, in the case that pickup unit of the pickup module 4 has much smaller contact area comparing with the entire surface area of the object 7, a pickup position far from the center of the mass of the object 7 or nearby edges of the object 7 might lead to unstable movement. As such, the choice of pickup position is critical to the pickup task. For example, the pickup unit of the pickup module 4 in contact with the object 7 is a suction gripper or suction gripper array, and the pickup force is applied in a direction perpendicular to the first surface of the object 7. Please refer to FIG. 3 again, while the image processing module 3 determines the available pickup area of the object 7, the size and/or width of the pickup unit may also be taken into consideration. For example, in an embodiment of the present disclosure, the distances between outer edges of the object 7 and the available pickup area is at least larger than 1/2 area widths of the pickup unit. Other values may be chosen depending on system requirements or user configurations as long as it can be ensured that the pickup module 4 would not pick up the object 7 at a pickup position that would lead to incomplete or insufficient contact of the pickup unit with the object 7. In embodiments of the present disclosure, the predetermined lifting distance can be determined by user, a size of the object or surrounding empty space, and the first time period can be determined according to the predetermined lifting distance, the predetermined first level of pickup force, a moving speed of the pickup module 4 or other suitable considerations.

[0020] The sensing module 5 is connected to the pickup module 4 and is configured for sensing sensor data in at least two dimensions corresponding to the pickup module 4. In an embodiment, during the first

time period of the first pickup attempt, the sensing module 5 obtains the sensor data and provides it to the control module 6. The sensor data may reflect the torques and forces that the pickup module 4 undergoes while picking up the object 7 at the pickup position A. Specifically in an embodiment of the present disclosure, the sensor data may reflect postures of the robotic object moving system 1 when the object 7 is lifted by the pickup module 4. In the case that the sensor data suggests there is huge difference in any of the sensor values while picking up the object comparing with its corresponding initial values while load free, it is implied that the object 7 may not be picked up at a proper position close to its center of mass. In the case that the sensor data suggests the offsets of the sensor values to the initial values are within a predetermined range, it can be assumed that the object 7 is picked up at a rather safe position not far from the center of mass. The sensing module 5 may include sensor in two or more dimensions, such as X, Y and/or Z, and may correspond to two or more types of sensor data, such as force and torque.

[0021] In embodiments of the present disclosure, the sensing module 5 may be integrated with the pickup module 4, or separately disposed with the pickup module 4. For example, the pickup module 4 and the sensing module may be implemented together as a robotic vacuum gripper with internal multi-axis force/torque sensor, or it can be implemented as an electrostatic gripper with force/torque sensor externally installed. The pickup module 4 and the sensing module 5 may be implemented by various types of grippers and sensors without departing from the spirit of the present disclosure, as long as they can provide above described functionalities to pick up objects at a position and measures sensor values in two or more dimensions.

[0022] The control module 6 is connected to the image processing module 3, the pickup module 4 and the sensing module 5, and is configured for controlling the pickup module 4. The control module 6 may receive the processed image data and the sensor data so as to determine the initial pickup position, the available pickup area, the sensor range and the adjusted pickup position according to criteria corresponding to each determination. In addition, the control module 6 may also determine whether the pickup task should be performed at adjusted pickup position, applied with adjusted force level and/or whether it is safe to proceed or should be aborted. In an embodiment of the present disclosure, the control module 6 determines whether to adjust the pickup position based on the sensor data by using a first pre-trained model in comply with a first criteria. Furthermore, the control module 6 adjusts the pickup position for obtaining an adjusted pickup position based on the sensor data and the available pickup area on the first surface of the object 7 by using a second pre-trained model in comply with a second criteria. In an embodiment, the adjusted pickup position is assumed as approximately or closer to the center of mass of the object 7, determined according to the sensor data and the available pickup area. The adjusted pickup position determined based on the sensor data and the available pickup area on the first surface of the object 7 by using the second pre-trained model in comply with the second criteria is referred to point “B” shown in FIG. 3 as an example. The pickup module 4 picks up the object 7 at the adjusted pickup position B and moves the object 7 from the starting location to a destination location.

[0023] In the robotic object moving system 1 of the present disclosure, the pickup position of the object 7 is adjusted by use of the sensor data obtained during the initial pickup attempt. Therefore, the stability of picking objects with unfixed size and uneven weight is improved. In

addition, compared to the conventional pickup solutions that utilize the center of the surface area of the object 7 to be the pickup position, the object 7 can be picked up first with a smaller picking force in the initial pickup attempt so as to adjust the pickup position according to the sensor data obtained during the initial pickup attempt, which would be closer to the center of mass of the object 7.

[0024] In an embodiment of the present disclosure, the robotic object moving system 1 is not limited to adjusting the pickup position of the object 7, but also adjusting the pickup force of picking up the object 7. The control module 6 adjusts the pickup force to the second level according to the sensor data by using the second pre-trained model, and the pickup module 4 picks up the object at the adjusted pickup position by applying the pickup force of the second level.

[0025] In an embodiment of the present disclosure, the sensor data includes at least torque values and force values in two or more dimensions. In an embodiment, the torque values include a six-degrees-of-freedom (6DoF) information, and the 6DoF information of the torque values include three translational degrees of freedom and three rotational degrees of freedom. The three translational degrees of freedom includes forward and backward movement along the X axis, left and right movement along the Y axis, and up and down movement along the Z axis. The three rotational degrees of freedom include rotation around the X axis, rotation around the Y axis, and rotation around the Z axis. The force values include a 6DoF information, and the 6DoF information of the force data includes three translational degrees of freedom and three rotational degrees of freedom.

[0026] The first criteria and the second criteria are explained through the relationship between the torque and force values and the first, second and third regions as illustrated in FIGs. 4A and 4B. Please note that the

number of the dimensions of the torque values and the force values are not limited in the present disclosure. In the embodiment shown in FIGs. 4A and 4B, the torque values have two dimensions, and the force value has one dimension. The torque value along the X axis is represents as T_x , the torque value along the Y axis is represents as T_y , and the force value along the Z axis is represents as F_z in FIGs. 4A and 4B.

[0027] Firstly, the first criteria include: a) in response to all of the torque values fallen into first regions, the first position is maintained as the pickup position; b) in response to the any of torque values fallen into second regions, the pickup position is adjusted to an adjusted pickup position; and c) in response to any of the torque values and the force value fallen into third regions, the pickup process of the object 7 is aborted. In the first criteria, the torque values are divided into three regions, so the control module 6 can determines whether to adjust the pickup position based on the regions where the torque values fallen into. In specific, in response to the torque values are fallen into the first regions, it represents that the torque values are slightly offset. Consequently, the first position needs not be adjusted, and is maintained as the final pickup position. In response to the torque values are fallen into the second regions, it represents that the torque values are significant offset, which implies there might be slight unbalance during the pickup process. Therefore, the first position needs to be adjusted to a second position that offers better balance. In response to the torque values are fallen into the third regions, it represents that the torque values are excessively offset, that is, the center of mass of the object 7 is far away from the center of the available pickup area. In such circumstance, it may cause danger or harm to pick up and move the object 7. In this circumstance, it is recommended to abort the pickup process of the object 7, otherwise the object 7 may be dropped or damaged

during the pickup process due to the extreme unbalance of weight distribution as demonstrated by the excessive torque values offset.

[0028] In an embodiment, the first criteria further include: d) in response to the force value fallen into first regions, the pickup force of the first level is maintained; and e) in response to the force value fallen into second regions, the pickup force is adjusted to a second level. In the first criteria, the force value is divided into three regions, such that the control module 6 can determine whether to adjust the pickup force based on the regions where the force value fallen into. In specific, in response to the force value is fallen into the first regions, it represents that the force value is only slightly offset. Consequently, the first level needs not be adjusted, and the first level is maintained as the final pickup force. In response to the force value is fallen into the second regions, it represents that the force value is significantly offset. Therefore, the first level needs to be adjusted, and it is adjusted to the second level according to the sensor data obtained in the first attempt so as to decrease the offset.

[0029] In an embodiment, the maximum absolute values of the first regions are less than the maximum absolute values of the second regions, and the maximum absolute values of the second regions are less than the maximum absolute values of the third regions. That is to say, the smaller the absolute values of the sensor data are, the more likely the pickup position is closer to the center of mass of the object 7 that does not create drastic change to the postures of the robotic arm system 1. In the case that the absolute values suggest significant changes, then it's better to adjust the pickup position so as to move it closer to the center of mass of the object 7.

[0030] In another embodiment, the relationship between the first, second and third regions may be defined specifically by thresholds. As shown in FIG. 4B, the first regions are defined as having offsets to initial

values smaller than first thresholds, the second regions are defined as having offsets to initial values between the first thresholds and second thresholds, the third regions are defined as having offsets to initial values larger than the second thresholds, and the second thresholds are larger than the first thresholds. The first thresholds and second thresholds of the torque values are determined according to at least one of the following: characteristics of the pickup module 4 and the available pickup area, and the first thresholds and second thresholds of the force values are determined according to at least one of the following: maximum force levels of the pickup module.

[0031] Regarding the second criteria, please refer to FIG. 4A again, the second criteria include: a) determining offset values of the torque values to the first regions; and b) determining the adjusted pickup position within the available pickup area according to the offset values. In an embodiment, the second criteria further include: c) in response to the adjusted pickup position within the available pickup area being unable to find, the picking up process of the object 7 is aborted. In the second criteria, the offset values of the torque values and the first regions are determined, so the control module 6 can determine the degree of the adjustment of the adjusted pickup position according to the offset values.

[0032] In an embodiment, the object 7 is a rectangular box with six sides. The pickup module 4 picks up the box through one of the six sides of the box. Specifically, the pose of the robotic object moving system 1 is adjusted by the control module 6 for allowing the pickup module 4 to align with one of the six sides of the box in the direction that the force is applied to the box so that the pickup module 4 can pick up the box properly. In an embodiment, the contact area of the pickup module 4 is smaller than that of the corresponding side of the box.

[0033] FIG. 5 is a schematic flow chart illustrating a method for moving an object with unknown weight distribution according to an embodiment of the present disclosure. The method for moving an object with unknown weight distribution of the present disclosure is applicable for the robotic object moving system 1 stated above. Please refer to FIG. 5, the control method of the present disclosure includes steps S1, S2, S3, S4, S5, S6 and S7. In the step S1, at least one image of the object 7 placed at a starting location is obtained. In the step S2, the image is processed to determine an available pickup area on a first surface of the object 7 and a first position corresponding to a center of the available pickup area as a pickup position. In the step S3, the object 7 is picked up by a pickup module 4 with a predetermined lifting distance for a first time period by applying a pickup force of a predetermined first level to the first surface at the pickup position. In the step S4, sensor data is obtained in at least two dimensions corresponding to the pickup module during the first time period. In the step S5, whether to adjust the pickup position based on the sensor data by using a first pre-trained model in comply with a first criteria is determined. In the step S6, the pickup position is adjusted for obtaining an adjusted pickup position based on the sensor data and the available pickup area on the first surface of the object by using a second pre-trained model in comply with a second criteria. In the step S7, the object 7 is picked up at the adjusted pickup position and the object 7 is moved from the starting location to a destination location.

[0034] In an embodiment, the method for moving an object with unknown weight distribution further includes steps of: adjusting the pickup force to a second level according to the sensor data by using the second pre-trained model; and picking up the object at the adjusted pickup position by applying the pickup force of the second level.

[0035] From the above descriptions, the present disclosure provides a robotic object moving system and a method for moving an object with unknown weight distribution. In the robotic object moving system and the method for moving an object, the pickup position of the object is adjusted by use of the sensor data obtained during an initial pickup attempt. Therefore, the stability of picking objects with unfixed size and uneven weight is improved. In addition, compared to the conventional picking pickup solutions that utilize the center of the surface of area of the object to be the pickup position, the object can be picked up first with a smaller picking force in the initial pickup attempt so as to adjust the pickup position according to the sensor data obtained during the initial pickup attempt, which would be closer to the center of mass of the object.

[0036] While the disclosure has been described in terms of what is presently considered to be the most practical and preferred embodiments, it is to be understood that the disclosure needs not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

WHAT IS CLAIMED IS:

1. A method for moving an object with unknown weight distribution, comprising:

- obtaining at least one image of the object placed at a starting location;

- processing the image to determine an available pickup area on a first surface of the object and a first position corresponding to a center of the available pickup area as a pickup position;

- picking up the object by a pickup module with a predetermined lifting distance for a first time period by applying a pickup force of a predetermined first level to the first surface at the pickup position;

- obtaining sensor data in at least two dimensions corresponding to the pickup module during the first time period;

- determining whether to adjust the pickup position based on the sensor data by using a first pre-trained model in comply with a first criteria;

- adjusting the pickup position for obtaining an adjusted pickup position based on the sensor data and the available pickup area on the first surface of the object by using a second pre-trained model in comply with a second criteria; and

- picking up the object at the adjusted pickup position and moving the object from the starting location to a destination location.

2. The method according to claim 1, further comprising:

- adjusting the pickup force to a second level according to the sensor data by using the second pre-trained model; and

- picking up the object at the adjusted pickup position by applying the pickup force of the second level.

3. The method according to claim 1, wherein the sensor data comprises at least torque values and force values in two or more dimensions.
4. The method according to claim 3, wherein the first criteria comprise:
 - in response to all of the torque values fallen into first regions, maintaining the first position as the pickup position,
 - in response to the any of torque values fallen into second regions, adjusting the pickup position to the adjusted pickup position;
 - wherein maximum absolute values of the first regions are less than maximum absolute values of the second regions.
5. The method according to claim 4, wherein the first criteria further comprise:
 - in response to any of the torque values and the force value fallen into third regions, aborting pickup process of the object;
 - wherein maximum absolute values of the second regions are less than maximum absolute values of the third regions.
6. The method according to claim 4, wherein the second criteria comprise:
 - determining offset values of the torque values to the first regions;
 - and
 - determining the adjusted pickup position within the available pickup area according to the offset values.
7. The method according to claim 6, wherein the second criteria further comprise:
 - in response to the adjusted pickup position within the available pickup area being unable to find, aborting picking up process of the object.
8. The method according to claim 3, wherein the first criteria further comprise:

in response to the force value fallen into first region, maintaining the pickup force of the first level; and

in response to the force value fallen into second region, adjusting the pickup force to a second level;

wherein absolute values of the first regions are smaller than absolute values of the second regions.

9. The method according to claim 1, wherein the available pickup area is a square area or a circular area with edges not exceeding outer edges of the object, and wherein distances between edges of the object and the available pickup area is at least larger than $1/2$ area widths of the pickup unit.
10. The method according to claim 1, wherein a pickup unit of the pickup module in contact with the object is a suction gripper or suction gripper array, and the pickup force is applied in a direction perpendicular to the first surface.
11. A robotic object moving system, comprising:
 - an image retrieving module, configured for obtaining at least one image of an object placed at a starting location;
 - an image processing module, connected to the image retrieving module, and configured for processing the at least one image to determine an available pickup area on a first surface of the object and a first position corresponding to a center of the available pickup area as a pickup position;
 - a pickup module, configured for picking up the object with a predetermined lifting distance for a first time period by applying a pickup force of a predetermined first level to the first surface at the pickup position;

a sensing module, connected to the pickup module, and configured for sensing sensor data in at least two dimensions corresponding to the pickup module during the first time period; and

a control module, connected to the image processing module, the pickup module and the sensing module, and configured for controlling the pickup module, and determining whether to adjust the pickup position based on the sensor data by using a first pre-trained model in comply with a first criteria, wherein the control module adjusts the pickup position for obtaining an adjusted pickup position based on the sensor data and the available pickup area on the first surface of the object by using a second pre-trained model in comply with a second criteria,

wherein the pickup module picks up the object at the adjusted pickup position and moves the object from the starting location to a destination location.

12. The robotic object moving system according to claim 11, wherein the control module adjusts the pickup force to a second level according to the sensor data by using the second pre-trained model, and the pickup module picks up the object at the adjusted pickup position by applying the pickup force of the second level.
13. The robotic object moving system according to claim 12, wherein the sensor data comprises at least torque values and force value in two or more dimensions.
14. The robotic object moving system according to claim 13, wherein the first criteria further comprise:
 - in response to all of the torque values fallen into first regions, maintaining the first position as the pickup position,

in response to the any of torque values fallen into second regions, adjusting the pickup position to the adjusted pickup position;

wherein the first regions are defined as having offsets to initial values smaller than first thresholds, the second regions are defined as having offsets to initial values between the first thresholds and second thresholds, and wherein the second thresholds are larger than the first thresholds.

15. The robotic object moving system according to claim 14, wherein the first criteria further comprise:

in response to any of the torque values and the force value fallen into third regions, aborting pickup process of the object;

wherein the third regions are defined as having offsets to initial values larger than the second thresholds.

16. The robotic object moving system according to claim 14, wherein the second criteria comprise:

determining offset values of the torque values to the first regions;
and

determining the adjusted pickup position within the available pickup area according to the offset values.

17. The robotic object moving system according to claim 16, wherein the second criteria further comprise:

in response to the adjusted pickup position within the available pickup area being unable to find, aborting pickup process of the object.

18. The robotic object moving system according to claim 13, wherein the first criteria further comprise:

in response to the force value fallen into the first regions, maintaining the pickup force at the first level; and

in response to the force value fallen into the second regions, adjusting the pickup force to a second level;

wherein the first regions are defined as having offsets to initial values smaller than first thresholds, the second regions are defined as having offsets to initial values between the first thresholds and second thresholds, and wherein the second thresholds are larger than the first thresholds.

19. The robotic object moving system according to claim 11, wherein the available pickup area is a square area or a circular area with edges not exceeding outer edges of the object, and wherein distances between edges of the object and the available pickup area is at least larger than $1/2$ area widths of the pickup unit.
20. The robotic object moving system according to claim 11, wherein a pickup unit of the pickup module in contact with the object is a suction gripper or suction gripper array, and the pickup force is applied in a direction perpendicular to the first surface.