

Description

Method for the two-dimensional determination of a current deflection and rotation of a load receiving means held on a trolley of a crane installation

The present invention relates to a method for the two-dimensional determination of a current deflection and rotation of a load receiving means held on a trolley of a crane installation in relation to an idle position of the load receiving means. The present invention also relates to a crane having a trolley and a load receiving means arranged on the trolley, comprising a camera arranged on the underside of the trolley and aligned in such a way that it records images of the top side of the load receiving means, and to an evaluation unit which is designed to carry out a method according to the invention.

Crane installations comprising a trolley and a load receiving means which is suspended from the trolley, generally by way of carrier cables or ropes, and which is designed for handling commercially available containers, for example, are known in a vast range of embodiments in the prior art. In such crane installations, the load assumed by the receiving means can be moved three-dimensionally in space by displacement of the trolley on the one hand and by alteration of the length of the carrier cables on the other. During the operation of the crane installation, the load receiving means experiences deflections and/or rotations which it is necessary to stabilize, in particular during automatic landing and loading cycles. Accordingly, current deflections and rotations of the trolley in relation to an idle position of the load receiving means are determined automatically in order, on the basis thereof,

to control an oscillation damping system acting on the load receiving means.

A known method for the two-dimensional determination of a current deflection and rotation of a load receiving means held on a trolley of a crane installation in relation to an idle position of the load receiving means is described in DE 198 36 103 A1. In said method, a semiconductor camera attached to the trolley of the crane installation records an image of a reflector mounted on the top side of the load receiving means and illuminated by an infrared illumination unit positioned directly next to the semiconductor camera. In the video image of the camera, the reflector represents an evaluable surface which can be compared with a reference surface of the reflector in the idle position of the load receiving means, which reference surface is stored in an evaluation unit. A current deflection and/or rotation of the load receiving means in relation to the idle position of the load receiving means can be calculated on the basis of such a comparison.

Basically, this known method has been successfully tried and tested in practice. A disadvantage of the method, however, is that installing the reflector may prove difficult depending on the design of the load receiving means since, for example, only very little installation space is available. If an active reflector is employed as a reflector, an additional power supply is required on the load receiving means, which generally is likewise associated with considerable overhead. Furthermore, an additional heating means is often required in order to keep the reflector free of snow and thus guarantee the operational viability of the system. In the event of a defective load receiving means, it must be further ensured that the same reflector is installed at the same position in the replacement load receiving means. Otherwise, a laborious

and time-consuming recalibration is necessary. Finally, a reflector and an infrared illumination unit are required in addition to the semiconductor camera for carrying out the method, which entails comparatively high costs.

Further methods for the two-dimensional determination of a current deflection and rotation of a load receiving means held on a trolley of a crane installation are known already from CN 111483914 A and US 2007/289931 A1.

Taking this prior art as a starting point, it is an object of the present invention to provide an improved method of the type cited in the introduction, as well as a crane installation designed to carry out the method.

In order to achieve this object, the present invention provides a method for the two-dimensional determination of a current deflection and rotation of a load receiving means held on a trolley of a crane installation in relation to an idle position of the load receiving means, which method comprises the steps of:

- a) arranging a camera on the trolley such that the camera captures images of the top side of the load receiving means;
- b) recording an image of the top side of the load receiving means in an idle position of the load receiving means and storing said idle position image;
- c) recording a current image of the top side of the load receiving means during the operation of the crane installation while the load receiving means is not in the idle position;
- d) capturing a plurality of geometric features present on the top side of the load receiving means and characteristic of the load receiving means in the current camera image recorded in step c);

- e) searching in the idle position image for the geometric features captured in step d); and
- f) determining the current two-dimensional deflection and rotation of the geometric features in relation to their idle position by comparing the positions of the geometric features in the current image with the positions of the geometric features in the idle position image.

A conventional digital video camera may be chosen as the camera arranged on a trolley in step a), thereby minimizing the camera purchasing costs. The geometric features captured in step d) are features characteristic of the load receiving means, which affords the advantage that there is no need for additional components, such as, for example, the reflectors described in the introduction or the like, to be positioned on the top side of the load receiving means. A further advantage associated with the selection of geometric features characteristic of the load receiving means is that the load receiving means can simply be replaced in the event of a defect by a new load receiving means of the same design without the requirement for a subsequent recalibration of the geometric features.

Overall, the present invention provides a very reasonably priced method for capturing current pendular movements of the load receiving means.

According to a first embodiment of the inventive method, the features captured in step d) are predefined features which, after being specified, are stored in an evaluation unit. In current camera images, therefore, the same geometric features are recorded every time and in step f) are compared with those in the idle position image in order to determine the

respective current two-dimensional deflection and rotation of the geometric features. This means that step e) also is not repeated for each new current camera image but is performed only once since the positions of the geometric features do not change in the idle position image and accordingly can be easily stored.

According to a second embodiment of the inventive method, the features captured in step d) are features that are selected automatically by the software used and may be different from current camera image to current camera image. Accordingly, step e) must be repeated for each new current camera image. This automatic selection of geometric features has the advantage that a properly conducted determination of the current two-dimensional deflection and rotation of the geometric features in relation to their idle position is always possible even under changing exposure conditions and shadowings. In the event that the load receiving means develops a defect, it can easily be replaced by a new load receiving means irrespective of whether the new load receiving means is identical in design to the old load receiving means since the geometric features are not predetermined but are automatically selected afresh each time the method is carried out. Only the idle position image must then be re-recorded once only.

According to an embodiment of the present invention, the determination of the current deflection and rotation of the load receiving means in step f) is performed by means of digital image processing, which is advantageous in terms of processing speed.

Preferably, steps c) to f) are repeated multiple times at closely spaced time intervals, a movement cycle of the load receiving means being determined based on the successive current deflections and rotations of the load receiving means. Oscillation damping can be optimally controlled based on such movement cycles.

According to an embodiment of the inventive method, control commands are generated in the evaluation unit based on the current deflections and rotations of the load receiving means determined in step f) and are forwarded to an oscillation damping system acting on the load receiving means, which oscillation damping system is then controlled based on the control commands.

In order to achieve the object cited in the introduction, the present invention further provides a system comprising a camera, in particular a digital camera, and an evaluation unit which is designed to carry out a method according to the invention.

Advantageously, the system further comprises an oscillation damping system.

In order to achieve the object cited in the introduction, the present invention further provides a crane installation having a trolley and a load receiving means arranged on the trolley, comprising a camera arranged on the underside of the trolley and aligned such that it captures images of the top side of the load receiving means, an evaluation unit, which is designed for carrying out a method according to one of the preceding claims, and an oscillation damping system acting on

the load receiving means and controlled by way of the evaluation unit.

Further features and advantages of the present invention will become apparent with reference to the following description taken in conjunction with the accompanying drawing, in which:

Figure 1 shows a schematic side view of a crane installation according to an embodiment of the present invention, and

Figure 2 shows a schematic perspective plan view of a load receiving means of the crane installation shown in Figure 1.

Figure 1 shows a crane installation 1 comprising a motorized trolley 2 which is movable in the X- and Y-direction and from which a load receiving means 4 is suspended via motor-driven carrier cables 3 which are movable in the Z-direction. The load receiving means 4 can be of a type such as is designed for handling commercially available containers, to cite just one example.

In order to carry out a method according to an embodiment of the present invention for the two-dimensional determination of a current deflection and rotation of the load receiving means 4 held on the trolley 2 in relation to an idle position of the load receiving means 4, in a first step a camera 5 is arranged on the trolley 2 such that it captures images of the top side of the load receiving means 4, as is indicated in the figure by the dashed lines 6. In the present example, the camera 5 is a conventional digital video camera. Also positioned on the trolley 2 in the present example are an evaluation unit 7 and

an oscillation damping system 8. However, the evaluation unit 7 and the oscillation damping system 8 may also be arranged at other positions and/or be integrated into already existing components of the crane installation 1.

In a further step, an image of the top side of the load receiving means 4 in an idle position of the load receiving means 4 is recorded by means of the camera 5 and said idle position image is stored in the evaluation unit 7.

During the subsequent operation of the crane installation 1, the camera 5 records current images of the top side of the load receiving means 4 and transmits these to the evaluation unit 7. In the evaluation unit 7, geometric features 9, 10, 11 characteristic of the load receiving means 4 and present on the top side of load receiving means 4 are then chosen automatically in each current camera image. Said geometric features 9, 10, 11 are then searched for in the idle position image, whereupon the current two-dimensional (X-Y plane in Figure 1) deflection and rotation of the geometric features 9, 10, 11 in relation to their idle position is determined by comparing the positions of the geometric features 9, 10, 11 in the current image with the positions of the geometric features 9, 10, 11 in the idle position image. Based on the current deflection and rotation, the evaluation unit 7 generates signals for controlling the oscillation damping system 8 and forwards these to the oscillation damping system 8. The more current camera images that are recorded in a predefined time interval and evaluated in the previously described manner, the more accurately can the movement cycle of the load receiving means 4 be determined based on the successive current deflections and rotations of the load receiving means 4, which enables an optimized oscillation damping.

A major advantage of the method described in the foregoing is that just a small number of components are required to carry it out, specifically only a camera 5, an evaluation unit 7 and an oscillation damping system 8. Additional components, such as reflectors or infrared illumination units, for example, are unnecessary, which makes for a very cost-effective construction.

The geometric features 9, 10, 11 are automatically determined afresh for each current camera image. Accordingly, the geometric features of different current camera images may be different from one another. This affords the advantage that a properly conducted determination of the current two-dimensional deflection and rotation of the geometric features in relation to their idle position is possible even under changing exposure conditions and shadowings.

In the event of a defect in the load receiving means 4, the latter can easily be replaced by a new load receiving means without the need for a recalibration of the geometric features 9, 10 and 11 subsequently. If a new load receiving means of different design from the old load receiving means 4 is chosen, it is simply necessary to record and store a new idle position image. Furthermore, the camera stream recorded by the camera 5 can also be used for example by the crane driver or a remote operator, which likewise constitutes an advantage.

According to an alternative embodiment of the method described in the foregoing, the features 9, 10, 11 captured in the current camera image can be predetermined features.

Accordingly, said features 9, 10 and 11 must be searched for

only once in the idle position image and then stored since they remain constant.

Although the invention has been illustrated and described in more detail on the basis of the preferred exemplary embodiment, the invention is not limited by the disclosed examples and other variations can be derived herefrom by the person skilled in the art without leaving the scope of protection of the invention.

Independent of the grammatical term usage, individuals with male, female or other gender identities are included within the term.

Claims

1. A method for the two-dimensional determination of a current deflection and rotation of a load receiving means (4) held on a trolley (2) of a crane installation (1) in relation to an idle position of the load receiving means (4), which method comprises the steps of:

- a) arranging a camera (5) on the trolley (2) such that the camera (5) captures images of the top side of the load receiving means (4);
- b) recording an image of the top side of the load receiving means (4) in an idle position of the load receiving means (4) and storing said idle position image;
- c) recording a current image of the top side of the load receiving means (4) during the operation of the crane installation (1) while the load receiving means (4) is not in the idle position;
- d) capturing a plurality of geometric features (9, 10, 11) present on the top side of the load receiving means (4) and characteristic of the load receiving means (4) in the current camera image recorded in step c);
- e) searching in the idle position image for the geometric features (9, 10, 11) captured in step d); and
- f) determining the current two-dimensional deflection and rotation of the geometric features (9, 10, 11) in relation to their idle position by comparing the positions of the geometric features (9, 10, 11) in the current image with the positions of the geometric features (9, 10, 11) in the idle position image.

2. The method as claimed in claim 1, characterized in that the features (9, 10, 11) captured in step d) are predefined features.

3. The method as claimed in claim 1, characterized in that the features (9, 10, 11) captured in step d) are automatically selected features.

4. The method as claimed in one of the preceding claims, characterized in that the determination of the current deflection and rotation of the load receiving means (4) in step f) is performed by means of digital image processing.

5. The method as claimed in one of the preceding claims, characterized in that steps c) and f) are repeated multiple times at closely spaced time intervals, and in that a movement cycle of the load receiving means (4) is determined based on the successive current deflections and rotations of the load receiving means (4).

6. The method as claimed in one of the preceding claims, characterized in that control commands are generated in the evaluation unit (7) based on the current deflections and rotations of the load receiving means (4) determined in step f) and are forwarded to an oscillation damping system (8) acting on the load receiving means (4), which oscillation damping system (8) is then controlled based on the control commands.

7. A system comprising a camera (5), in particular a digital camera, and an evaluation unit (7) which is designed to carry out a method as claimed in one of the previous claims.

8. The system as claimed in claim 7, further comprising an oscillation damping system (8).

9. A crane installation (1) having a trolley (2) and a load receiving means (4) arranged on the trolley (2), comprising a camera (5) arranged on the underside of the trolley (2) and aligned such that it captures images of the top side of the load receiving means (4), an evaluation unit (7) which is designed to carry out a method as claimed in one of claims 1 to 6, and an oscillation damping system (5) acting on the load receiving means (4) and controlled via the evaluation unit (7).