

Description

Loading of a load with a crane system

The present invention relates to a method for the loading of a load with a crane system, a crane system for the loading of a load and a computer program.

In container terminals, goods trains and heavy goods vehicles are loaded, in particular loaded and unloaded. Hereby, a crane driver manually controls a lifting device of a crane. In order to design the loading to be as efficient, economic and safe as possible, it is desirable to carry out as many processes as possible automatically.

It is therefore an object of the present invention to provide an improved concept for loading a load with a crane system, which enables an automated loading of the load.

According to the invention, this object is achieved by a method and a crane system as well as a computer program according to the independent claims. Advantageous developments and further embodiments are the subject matter of the dependent claims.

The improved concept is based upon the idea of imaging a transport vehicle that is to be loaded or unloaded, with a camera system and of analyzing the camera data by means of an artificial neural network. By means of pre-defined markers for the recognition of which the neural network, in particular, has been trained, a lifting device is controlled for automatic loading of the load.

According to a first independent aspect of the improved concept, a method for loading a load with a crane system is provided. Thereby, by means of a camera system of the crane system, at least one image data stream is created. The at least one image data stream is analyzed by means of a computer unit of the crane system on the basis of an, in particular, trained artificial neural network, in particular, continuously, periodically and/or repeatedly. By means of the computer unit, on the basis of the analysis, a first marker is recognized in a first single image of the at least one image data stream and a second marker is recognized in a second single image of the at least one image data stream. By means of the computer unit, a position of the first marker and a position of the second marker are determined and the load is loaded automatically by means of a lifting device of the crane system, dependent upon the positions of the markers.

An image data stream can be considered herein, and in the following, as a temporal sequence of a plurality of single images which can also be designated frames. In particular, the single images can be recorded at a pre-defined sampling rate whereby the sampling rate can be, for example, in a range of 10 ms to 10 s, for example, in the order of magnitude of 100 ms or approximately 100 ms. In other words, the at least one image data stream involves at least one video stream.

The camera system generates the at least one image data stream, in particular by imaging one or more target regions of the camera system in a vicinity of the crane system. In particular, the target regions lie in a region in which a transport vehicle which is to be loaded or unloaded by means of the method is situated for this purpose.

The artificial neural network is, in particular, a neural

network which has been trained for pattern recognition in image data. For example, this can be a "convolutional neural net" (CNN).

That the at least one image data stream is analyzed making use of the neural network can be understood, for example, in that each image data stream which contains the at least one image data stream is analyzed, whereby for the analysis, each of the single images of the corresponding image data stream is analyzed, for each of the single images, therefore, in particular a pattern recognition is carried out.

The first and the second markers are situated, in particular, at or on the transport vehicle. In particular, these can be components firmly installed in or fastened onto the transport vehicle, for example, functional components. Alternatively or additionally, the markers can also be provided in a dedicated way for the purpose of pattern recognition.

That the first and the second markers are recognized in the respective single image by means of the analysis can be understood in that on the basis of the analysis by the neural network, a pre-defined and/or learned pattern is present in the respective single image, wherein the pattern has been pre-defined or learned, in particular, by means of training of the neural network.

The first and the second markers are situated, in particular, at different positions of the transport vehicle, in particular, on opposite ends of the transport vehicle. The designation "end" of the transport vehicle thereby relates to a longitudinal direction or longitudinal axis of the transport vehicle. In particular, the first marker is situated on a

first longitudinal end of the transport vehicle and the second marker is situated on a second longitudinal end of the transport vehicle lying opposite the first longitudinal end.

The longitudinal direction of the transport vehicle can be understood, for example, as a direction along which the transport vehicle can move, if relevant in particular, in a neutral setting of a steering system of the transport vehicle.

The transport vehicle can be, for example, a heavy goods vehicle, a heavy goods trailer or a heavy goods articulated trailer or a train wagon. In the case of a train wagon, for example, rails can be provided on which the train wagon can be moved into the target region or out of the target region. In this case, the longitudinal axis of the transport vehicle corresponds, in particular, to an alignment or longitudinal direction of the rails.

The load can be, in particular, a receptacle, in particular a container, for example, a sea freight container, for example, according to the standard ISO 668 (sixth edition, 2013).

The transport vehicle is, in particular, a vehicle which is to be loaded or unloaded by the crane or the crane system and which, in particular, transports the load after the loading or before the unloading.

The neural network is, in particular, a software module which is stored on the computer unit.

The positions of the first and the second marker are, in particular, respective real positions, that is, absolute positions, given by corresponding coordinates in relation to a

pre-defined coordinate system which is connected, in particular, to a frame of the crane system or a base on which the transport vehicle is situated. In particular, the position of the respective marker can be unambiguously defined by a position of the camera system in relation to the pre-defined coordinate system and an arrangement or relative position of the marker within the single image. As an approximation, the position of the marker alone can be defined by the respective position of the camera system.

The lifting device includes, in particular, a container spreader and can also be referred to as a load receiving means or spreader. In particular, the lifting device includes a gripping device by means of which the load, in particular the container, can be gripped and lifted from the transport vehicle or can be placed on the transport vehicle.

The lifting device includes, for example, a frame, in particular a telescopic frame which can be extended and/or set according to a length of the container. Gripping elements of the lifting device can engage and be locked, for example, in corresponding corner fittings of the container.

That the load is loaded automatically by means of the lifting device can be understood to mean, in particular, that at least one operating parameter of the lifting device or of the crane system is set autonomously without any manual engagement, by the crane system dependent upon the positions of the markers, in order to load the load. For example, the loading can take place fully automatically, that is, without any intervention by an operator.

According to the improved concept, settings of the crane system, in particular of the lifting device, for loading the load can be configured to be partly or fully automatic. In particular, the positions of the markers are determined fully automatically from the at least one image data stream. The loading of the load can thus take place at least partly automatically or possibly fully automatically and therefore particularly efficiently, in particular, in a time-saving and cost-saving manner and with enhanced safety.

Through the use of the neural network, a recognition and position determination of the markers is possible with a high degree of reliability, so that a high level of automation can be enabled. Further advantages which result from the use of the neural network are its individual trainability, that is, its specific adaptation to the optical appearance of the markers, or pre-defined pattern and its high speed during pattern recognition.

According to at least one embodiment of the method, by means of the computer unit, on the basis of the analysis unit, a third marker is recognized in a third single image of the at least one image data stream and a fourth marker is recognized in a fourth single image. By means of the computer unit, the positions of the third and fourth markers is determined. The load is loaded by means of the lifting device dependent upon the positions of the first, the second, the third and the fourth marker.

By means of the additional recognition and evaluation of the third and the fourth marker, an enhanced reliability of the method, an increased speed or a redundancy and thereby an enhanced level of safety, can be achieved. The above

statements regarding the first and second markers apply analogously for the third and fourth markers.

According to at least one embodiment, the camera system is moved during the generation of the at least one image data stream along the longitudinal direction of the transport vehicle. The position of the first marker is determined by means of the computer unit dependent upon a first momentary position of the camera system when the first marker has been recognized. The position of the second marker is determined by means of the computer unit dependent upon a second momentary position of the camera system when the second marker has been recognized.

In particular, the crane system can contain a control system and a drive system, wherein the control system can control the drive system for moving the camera system. Thereby, the computer unit is coupled, in particular, to the control system.

During the movement of the camera system along the longitudinal direction for generating the at least one image data stream, the transport vehicle is, for example, stationary, particularly in relation to the pre-defined coordinate system.

A momentary position of the camera system can be understood, in particular, as a position of the camera system, in particular, with regard to the pre-defined coordinate system at a time point of the recognition of the respective marker. For example, each single image of the at least one image data stream can be assigned to a time stamp. The momentary position then corresponds, for example, to the position of the camera

system at a time point that is given by the time stamp of the respective single image in which the corresponding marker was recognized.

The first and second momentary position can correspond, for example, to respective positions of different components or constituents of the camera system.

In particular, the camera system has, for example, one camera per image data stream of the at least one image data stream. The first momentary position of the camera system then corresponds, for example, to a momentary position of the camera by which the first marker was recognized. Accordingly, the second momentary position is given, for example, by a momentary position of the camera by means of which the second marker was recognized.

In such embodiments, the transport vehicle is therefore scanned by means of the camera system. Advantageously, in this way, the markers can be sought so that an exact position of the transport vehicle at the beginning of the method or a type or a length of the transport vehicle or an extent of the load at the beginning of the method must not necessarily be known. Accordingly, an increased level of automation is enabled.

In addition, in some embodiments, the position determination of the markers is enabled purely by the corresponding momentary position of the camera system. If a corresponding accuracy is sufficient for the position determination for the particular use then, for example, a determination of the arrangement of the respective marker within the respective single image in order to determine the position of the markers can be dispensed with.

According to at least one embodiment, a first image data stream of the at least one image data stream is generated by means of a first camera of the camera system arranged at a first end of the lifting device. For the analysis of the at least one image data stream, the first image data stream is analyzed by means of the computer unit, making use of the neural network. The first marker is recognized by the computer unit on the basis of the analysis of the first image data stream in the first single image. Thereby, the first momentary position corresponds to a momentary position of the first camera.

The first end of the lifting device is, in particular, a first longitudinal end, that is, a first end in relation to a longitudinal direction of the lifting device. The longitudinal direction of the lifting device can correspond or approximately correspond, in particular, during the method or during the scanning, for example, to the longitudinal direction of the transport vehicle.

The first single image is, for example, a single image of the first image data stream.

According to one embodiment, a second image data stream of the at least one image data stream is generated by means of a second camera of the camera system arranged at a second end of the lifting device opposite to the first end of the lifting device. For the analysis of the at least one image data stream, the second image data stream is analyzed by the computer unit making use of the neural network. The second marker is recognized by the computer unit on the basis of the analysis of the second image data stream in the second single

image. Thereby, the second momentary position corresponds to a momentary position of the second camera.

The second single image is, in particular, a single image of the second image data stream.

In that, for the recognition of the markers, a separate camera is provided in each case, the scan procedure is accelerated since the overall transport vehicle does not have to be scanned, the camera system therefore does not have to be moved over the entire length of the transport vehicle.

According to at least one embodiment, a third image data stream of the at least one image data stream is generated by a third camera of the camera system arranged at the first end of the lifting device. The third image data stream is analyzed by the computer unit making use of the neural network. The third marker is recognized by the computer unit on the basis of the analysis of the third image data stream in the third single image. The position of the third marker is determined by the computer unit dependent upon a third momentary position of the camera system, which corresponds to a momentary position of the third camera when the third marker has been recognized.

According to one embodiment, a fourth image data stream of the at least one image data stream is generated by a fourth camera of the camera system arranged at the second end of the lifting device. The fourth image data stream is analyzed by the computer unit making use of the neural network and the first marker is recognized by the computer unit on the basis of the analysis of the fourth image data stream in the fourth single image. The position of the fourth marker is determined by the computer unit dependent upon a fourth momentary position of

the camera system, which corresponds to a momentary position of the fourth camera when the fourth marker has been recognized.

In such embodiments, therefore, two markers are recognized at each longitudinal end of the transport vehicle. Thereby, the recognition of the third and fourth marker can be regarded, for example, as redundant to the recognition of the first or the second marker. By this means, a stability and reliability of the method can be enhanced.

According to at least one embodiment, the first marker contains a buffer or buffer plate of the transport vehicle, in particular if the transport vehicle is configured as a train wagon or has one such. Alternatively or additionally, the first marker can contain a load fixing means with which, for example, a container placed on the transport vehicle can be fixed or positioned. Such load fixing means can also be referred to as pins.

According to at least one embodiment, the buffer and/or the load fixing means is recognized as the first marker on the basis of the analysis of the at least one image data stream, in particular, the first image data stream, making use of the neural network.

According to at least one embodiment, the second marker contains a further buffer of the transport vehicle and/or a further load fixing means of the transport vehicle.

According to at least one embodiment, the further buffer and/or the further load fixing means of the transport vehicle is recognized as the second marker on the basis of the

analysis of the at least one image data stream, in particular, the second image data stream, making use of the neural network.

Corresponding embodiments arise directly also for the third and/or fourth marker.

The individual markers can therefore contain, in particular, a buffer or a load fixing means or a combination of the buffer and the load fixing means.

The use of buffers for the markers has the advantage, in particular, that train wagons as transport vehicles usually have such buffers. In addition, the buffers are always arranged at respective longitudinal ends of the train wagon, so that they are particularly suitable as markers. Furthermore, the geometrical form of the buffers of train wagons is comparatively uniform. In addition, it has been found that neural networks are well suited to recognizing buffers in the image data streams.

The use of load fixing means for the buffers has the advantage, in particular, that transport vehicles for the transport of containers usually have such load fixing means in order to fix the containers or position them in a defined manner. The load fixing means are also advantageously usually located on respective longitudinal ends of train wagons or goods vehicles trailers. The load fixing means can also be reliably recognized making use of the neural network.

The neural network is trained, in particular, for recognizing buffers and/or load fixing means in the image data streams.

According to at least one embodiment, the position of the first marker is determined by the computer unit dependent upon an arrangement of the first marker in the first single image.

According to at least one embodiment, the position of the second marker is determined by the computer unit dependent upon an arrangement of the second marker in the second single image.

According to at least one embodiment, the position of the third marker is determined by the computer unit dependent upon an arrangement of the third marker in the third single image and/or the position of the fourth marker is determined by the computer unit dependent upon an arrangement of the fourth marker in the fourth single image.

An arrangement of one of the markers in the respective single image can be understood to be the corresponding representation of the respective marker in the corresponding single image. The arrangement or the position of the representation of the marker in the single image can be determined after or during the recognition of the marker, for example, making use of the neural network or on the basis of a further software module of the computer unit.

Embodiments in which the position of the respective marker is determined dependent upon its arrangement in the single image are advantageous, in particular, in combination with embodiments in which the respective momentary position of the camera system is used for determining the position of the marker. In particular, through the combination of the momentary position of the camera system with the arrangement of the respective marker in the corresponding single image,

the position of the corresponding marker in relation to the pre-defined coordinate system can be determined with greater accuracy.

According to at least one embodiment, on the basis of the positions of the first and second markers, a spacing or a first spacing of the first and second markers from one another is determined by the computer unit. The load is loaded by the lifting device dependent upon the spacing.

The spacing represents, in particular, a spacing along the longitudinal axis of the transport vehicle.

If one of the markers contains a plurality of objects, for example, a buffer and a load fixing means, then the position of the marker can also be defined unambiguously. For example, this may involve the position of one of the two objects or a mean position of the objects.

According to at least one embodiment, on the basis of the positions of the third and fourth markers, a further or second spacing of the third and fourth markers from one another is determined by the computer unit. The load is loaded by the lifting device dependent upon the further spacing.

The determination of the further spacing can be regarded, for example, as redundant for determining the spacing.

According to at least one embodiment, on the basis of the positions of the first and fourth markers, a third spacing of the first and fourth markers from one another is determined and/or on the basis of the positions of the second and third markers, a fourth spacing of the second and third markers from

one another is determined. The load is loaded by the lifting device dependent upon the first, second, third and/or the fourth spacing.

In particular, one of the four spacings is sufficient to load the load automatically by the lifting device. Accordingly, a reliability of the method can be further increased in that even in the case that individual markers are not recognized, at least one of the spacings can still be determined and used for automated loading.

According to at least one embodiment, the computer unit is configured, on the basis of at least one of the spacings, to determine a type of the transport vehicle and/or the load, in particular a length of the transport vehicle and/or the load. In addition, from the spacing, a height of the load or of the combination of transport vehicle and load can be determined.

On the basis of corresponding norm stipulations, making use of the determined spacings, the corresponding wagon type or the type of the load can be unambiguously determined. If relevant, for unambiguous determination, further information from the analysis of the at least one image data stream can also be used, for example, the arrangement of the load fixing means on the transport vehicle.

According to at least one embodiment, at least one operating parameter of the lifting device, the drive system, the control system and/or the crane system is set dependent upon the positions of the first, second, third and/or fourth marker and/or the first, second, third and/or fourth spacing by the control system of the crane system, in order to load the load automatically.

The computer unit can transfer information, in particular, relating to the type of the transport vehicle, for example, the length of the transport vehicle, or relating to the positions or spacings of the markers to the control system. Dependent thereon, the control system can then transfer an order defined according to the set operating parameters to the drive system, so that the load is loaded.

The at least one operating parameter contains, in particular, an extension length of the lifting device and/or a lowering height of the lifting device. The at least one operating parameter can also contain a lowering speed or a lifting speed and/or a rotary speed of the drive.

According to a further independent aspect of the improved concept, a crane system for loading a load is also provided. The crane system has a camera system, a computer unit with an artificial neural network, a control system and a lifting device. The camera system is configured to generate at least one image data stream. The computer unit is configured to analyze the at least one image data stream making use of the neural network. The computer unit is configured, on the basis of the analysis of the at least one image data stream, to recognize a first marker in a first single image of the at least one image data stream and to recognize a second marker in a second single image of the at least one image data stream. The computer unit is configured to determine a position of the first marker and a position of the second marker. The control system which contains, for example, a control unit or a control device is configured to control the lifting device dependent upon the positions of the markers in order to load the load automatically.

The control system is coupled, in particular, to the computer unit, for example, via an internet protocol (IP) connection.

The control system can contain the computer unit entirely or partially, or vice versa.

According to at least one embodiment, the crane system has a drive system and the control system can control the drive system to move the lifting device. The drive system contains, in particular, a motor and a transmission.

According to at least one embodiment of the crane system, the control system is configured to move the camera system during the generation of the at least one image data stream along a longitudinal direction of a transport vehicle. The computer unit is configured to determine the position of the first marker dependent upon a first momentary position of the camera system when the first marker has been recognized. The computer unit is configured to determine the position of the second marker dependent upon a second momentary position of the camera system when the second marker has been recognized.

According to at least one embodiment of the crane system, the control system is configured to control the drive system or a further drive system of the crane system in order to move the camera system along the longitudinal direction of the transport vehicle.

According to at least one embodiment, the camera system has a first camera arranged at a first end of the lifting device in order to generate a first image data stream of the at least one image data stream. The computer unit is configured, for

the analysis of the at least one image data stream, to analyze the first image data stream making use of the neural network and to recognize the first marker on the basis of the analysis of the first image data stream. Thereby, the first momentary position corresponds to a momentary position of the first camera.

According to at least one embodiment, the camera system has a second camera arranged at a second end of the lifting device opposite the first end, in order to generate a second image data stream of the at least one image data stream. The computer unit is configured, for the analysis of the at least one image data stream, to analyze the second image data stream making use of the neural network and to recognize the second marker on the basis of the analysis of the second image data stream. The second momentary position thereby corresponds to a momentary position of the second camera.

According to at least one embodiment, the camera system has a third camera arranged at the first end of the lifting device, in order to generate a third image data stream, and a fourth camera arranged at the second end of the lifting device, in order to generate a fourth image data stream. The computer unit is configured to analyze the third and the fourth image data stream making use of the neural network. The computer unit is configured, on the basis of the analysis of the third image data stream, to recognize a third marker in a third single image of the third image data stream and, on the basis of the analysis of the fourth image data stream, to recognize a fourth marker in a fourth single image of the fourth image data stream. The computer unit is configured to determine a position of the third marker dependent upon a third momentary position of the third camera when the third marker has been

recognized and to determine a position of the fourth marker dependent upon a fourth momentary position of the fourth camera when the fourth marker has been recognized. The control system is configured to drive the lifting device of the crane system dependent upon the positions of the first, the second, the third and the fourth marker in order to load the load automatically.

According to at least one embodiment, the lifting device has a rectangular or substantially rectangular base shape and the first and the second camera are arranged at respective corners of the rectangular base shape.

According to at least one embodiment, the third and fourth cameras are arranged at further respective corners of the rectangular base shape. The four cameras are therefore arranged at four different corners of the rectangular base shape.

The lifting device can be configured, for example, as a container spreader. The lifting device can have, for example, an H-shaped or substantially rectangular telescopic frame, wherein the telescopic frame defines, for example, the rectangular base shape of the lifting device.

According to at least one embodiment, the crane system is configured as a container crane or container gantry crane, in particular for transferring or loading ISO containers.

Further embodiments of the crane system according to the improved concept arise directly from the described embodiment forms of the method for loading a load according to the improved concept and vice versa. In particular, individual

features and corresponding explanations relating to the different embodiments of the method according to the improved concept can be transferred analogously to corresponding embodiments of the crane system according to the improved concept. For example, a crane system according to the improved concept can be configured or programmed to carry out a method according to the improved concept or the crane system carries out a method according to the improved concept.

According to a further independent aspect of the improved concept, a training method for training a crane system for loading a load, in particular, for training a crane system in accordance with the improved concept, or an artificial neural network for such a crane system or method is provided. For this purpose, by a camera system of the crane system, at least one training image data stream is generated and analyzed by an untrained or pre-trained artificial neural network. In particular, by an operator, reference single images are selected from the at least one image data stream, on which markers of a pre-defined type are represented. The selected single images are pre-defined as a reference, in particular a positive reference for the neural network, in order to train the neural network.

According to at least one embodiment of the method for loading a load according to the improved concept, the crane system or the artificial neural network has been trained according to a training method in accordance with the improved concept.

According to at least one embodiment of the method for loading a load in accordance with the improved concept, the method includes the method steps of an embodiment of the training method for training a crane system for loading a load in

accordance with the improved concept. Thereby, the image data stream is used as a training data stream.

By this means, the neural network can advantageously be further trained during productive operation, so that the accuracy of the analysis in normal operation can be continuously improved.

According to at least one embodiment of the crane system in accordance with the improved concept, the crane system or the neural network of the crane system has been trained according to a training method in accordance with the improved concept.

According to a further independent aspect of the improved concept, a computer program with commands is provided. On execution of the computer program by a crane system in accordance with the improved concept, in particular by a computer unit of the crane system, the commands cause the crane system to carry out a method for loading a load in accordance with the improved concept.

According to a further independent aspect of the improved concept, a computer-readable storage medium is provided on which a computer program in accordance with the improved concept is stored.

The invention will now be described in greater detail by reference to actual exemplary embodiments and associated schematic drawings. In the figures, the same or functionally equivalent elements have been given the same reference signs. The description of the same or functionally equivalent elements will, where relevant, not necessarily be repeated in relation to different drawings.

In the figures:

FIG 1 is a schematic representation of an exemplary embodiment of a crane system according to the improved concept;

FIG 2 is a schematic flow diagram of an exemplary embodiment of a method for loading a load according to the improved concept; and

FIG 3 is exemplary single images in a further exemplary embodiment of a method according to the improved concept.

FIG 1 shows an exemplary embodiment of a crane system 8 according to the improved concept. The crane system 8 is configured, for example, as a container crane and has, in particular, a frame 7. The crane system 8 also has a container spreader 27 which is movably connected, for example via a crane trolley 31, to the frame 7.

The crane system 8 also has a control system 26 which is configured to drive the crane trolley 31 for moving the container spreader 27. Furthermore, the control system 26 can drive the container spreader 27, for example, in such a way that an extension length of a telescopic frame 32 of the container spreader 27 can be set. In addition, the control system 26 can, for example, control a height of the container spreader 27.

The telescopic frame 32 of the container spreader 27 has, for example, a rectangular base shape. The crane system 8 has, for

example, a camera 9, 10, 11, 12 at each corner of the telescopic frame 32, wherein the cameras 9, 10, 11, 12 are each arranged and aligned such that their direction of view looks downward, in particular, in the direction of a transport vehicle 30 which is configured in FIG 1, for example, as a train wagon.

The cameras 9, 10, 11, 12 can be accommodated, for example, in respective steel housings in order to keep an impairment by rain or dirt as low as possible. For example, the cameras 9, 10, 11, 12 each have lenses with an angle of 20 to 25 degrees, in particular, approximately 22 degrees.

At a first end, the transport vehicle 30 has a first buffer 14 and a third buffer 16 and at an opposite second end, a second buffer 15 and a fourth buffer 17. The transport vehicle 30 can move, for example, along a longitudinal direction 29 of the transport vehicle 30 which corresponds, for example, to a rail direction.

The transport vehicle 30 carries, for example, a container 28, in particular a normed ISO container. For fixing or positioning the container 28 on the transport vehicle 30, the transport vehicle 30 optionally has a first load fixing means 18 and a third load fixing means 20 on the first end and a second load fixing means 19 and a fourth load fixing means 21 on the second end of the transport vehicle 30.

The crane system 8 also has a computer unit 13 which is coupled, for example, to the control system 26. An artificial neural network is stored on the computer unit 13. The neural network has been trained for pattern recognition in image data, in particular camera images. In particular, the neural

network has been trained to recognize representations of the buffers 14, 15, 16, 17 and/or representations of the load fixing means 18, 19, 20, 21 in respective image data streams of the cameras 9, 10, 11, 12.

Furthermore, the computer unit 13 can have a computer-readable storage medium 34 in accordance with the improved concept, on which a computer program according to the improved concept is stored.

The functional method of the crane system 8 will now be described in greater detail making reference to FIGs 2 and 3.

FIG 2 shows a flow diagram of a method for loading a load in accordance with the improved concept.

In step 1 of the method, by the cameras 9, 10, 11, 12, respective image data streams are generated. For this purpose, the container spreader 27 is moved over the transport vehicle 30, in particular, along the longitudinal direction 29. The image data streams can be transferred, for example, by the respective camera signals as a live stream to the computer unit 13. The computer unit 13 can read in the image data streams by digital or analogue means and in step 2 of the method, can analyze it making use of the neural network.

The scan procedure in step 1 can be started, for example, by the control system 26 or an automation unit of the crane which is coupled to the computer unit 13 and the control system 26. It can thereby be ensured, for example, that the transport vehicle 30 is situated at a stationary position and is initially no longer moved, in particular, during the entire scan procedure.

During the scan procedure, the computer unit 13 receives, for example, from the control system 26 or the automation unit, the respective central position of the container spreader 27. In particular, the computer unit 13 receives the central position of the container spreader 27 for each single image of the image data streams or for a pre-defined portion of the single images.

Depending on the rate at which the central position is prepared, a plurality of single images can also be assigned to the same central position. For example, the rate at which the central position is prepared can be selected dependent upon a scan rate, that is, a movement speed of the container spreader 27.

By way of example, for instance, every 100 ms, the central position can be prepared when the speed of the container spreader 27 or the scan speed is 0.3 meters per second. This has proved to be advantageous for an accuracy of the method.

In step 2 of the method, the computer unit analyzes the image data streams of the cameras 9, 10, 11, 12.

At a particular time point, for example, the first buffer 14 is located in the viewing direction of the first camera 9. The neural network recognizes in a corresponding single image of the associated image data stream that the pre-defined marker is imaged. Similarly, at corresponding time points, the second buffer 15 is situated in the viewing direction of the second camera 10, the third buffer 16 is situated in the viewing direction of the third camera 11 and the fourth buffer 17 is situated in the viewing direction of the fourth camera 12. The

neural network recognizes the presence of a pre-defined marker in the corresponding image data streams.

In step 3 of the method, by the computer unit 13, corresponding positions of the buffers 14, 15, 16, 17 in relation to a reference coordinate system, which is fixed, for example, by the frame 7, are determined. For this purpose, the respective central positions of the buffers 14, 15, 16, 17 are calculated on the basis of the respectively set extension length of the container spreader 27 and the current central position of the container spreader 27. In the calculation of the central positions of the buffers 14, 15, 16, 17, optionally an arrangement of the markers can also be taken into account within the respective single images, in order to increase the accuracy.

In step 4 of the method, from the determined positions of the buffers 14, 15, 16, 17, corresponding spacings between the first buffer 14 and the second buffer 15 and between the third buffer 16 and the fourth buffer 17 are determined. Through taking account of the detection results of the camera pairs of first and second camera 9, 10 and of third and fourth camera 11, 12, a particularly great stability of the method is achieved.

From the spacings that are determined, in step 5 of the method, by the computer unit 13 or by the automation unit, an exact length of the transport vehicle 30 can be determined and on the basis thereof, an exact type of the transport vehicle 30 can be determined, for example, by means of stored data in a database in the computer unit 13 or the automation unit.

In step 6 of the method, the information regarding the exact vehicle type can be used to load the load 28 automatically by the container spreader 27. For this purpose, dependent upon the container type, operational positions of the container spreader 27 or of the crane system 8 can be set. Alternatively or additionally, a logistical coordination of the loading can take place on the basis of the wagon type.

The corresponding information for automatic loading can be provided, for example, by the control system 26, the computer unit 13 or the automation unit or by a higher-level crane management system.

In place of the buffer 14, 15, 16, 17 or in addition thereto, the load fixing means 18, 19, 20, 21 can be used as pre-defined markers or patterns for recognizing the neural network.

In FIG 3, by way of example, single images 22, 23, 24, 25 from the cameras 9, 10, 11, 12 are shown, wherein the first single image 22 corresponds to a single image from the camera 9, the second single image 23 corresponds to a single image from the second camera 10, the third single image 24 corresponds to a single image from the third camera 11 and the fourth single image 25 corresponds to a single image from the fourth camera 12.

In FIG 3, for example, the transport vehicle 30 is shown without the load 28.

The single images 22, 23, 24, 25 can be, for example, training images for training the neural network during a training process in accordance with the improved concept.

For the creation of training data for the training of the neural network, items of label information are assigned to the single images 22, 23, 24, 25, that is, relevant information regarding where in the image the desired search pattern is located.

For the purpose of the training, the single images 22, 23, 24, 25 can be extracted, for example, directly from a video sequence, that is, a corresponding training image data stream and stored. For this purpose, for example, an operator can position bounding boxes at corresponding positions of the buffers 14, 15, 16, 17 or the load fixing means 18, 19, 20, 21 in order to adjust corresponding weights of the neural network.

The training of the neural network can take place, for example, by a CPU or a GPU. The training can take place, for example, on the basis of a cloud computer or another computer system, externally to the crane system, since for training the neural network, large computing capacities can be required.

According to the improved concept, a partially or completely automated loading of a load is enabled by a crane system. Through the use of the neural network, a particularly high degree of reliability, safety and speed of the method is enabled. In particular, it has been found that the marker positions can be determined on the basis of the improved concept with an accuracy of 1 - 2 cm.

Disruptive influences can be further reduced if additional information from the crane automation system is available, such as for example, a type of the transport vehicle to be

expected or a height of the transport vehicle to be expected or the load on the transport vehicle. With the aid of plausibility testing, falsely recognized positions which are caused, for example, by dirt or weather influences are rejected in order to increase the stability of the evaluation. This can be enabled, for example, by the provision of the redundant camera pairs.

As the cameras, for example, analogue or IP cameras can be used. For remote control purposes, these cameras can be installed on the crane in any case, so that no additional costs for hardware and installation are incurred for the cameras.

Further advantages of the improved concept are relatively low acquisition costs and a small time cost for the commissioning and calibration of the system. A servicing cost is also low, due to the use of the cameras and possibly corresponding protective housings. Through the use of the neural network, a particularly high detection rate and reliability are achieved.

Claims

1. A method for loading of a load (28) with a crane system (8), characterized in that by means of a camera system (9, 10, 11, 12) of the crane system (8), at least one image data stream is generated;
the at least one image data stream is analyzed by a computer unit (13) of the crane system (8) on the basis of an artificial neural network;
by means of the computer unit (13), on the basis of the analysis, a first marker (14, 18) is recognized in a first single image (22) of the at least one image data stream and a second marker (15, 19) is recognized in a second single image (23) of the at least one image data stream;
by means of the computer unit (13) a position of the first marker (14, 18) and a position of the second marker (15, 19) are determined; and
the load (28) is loaded automatically by a lifting device (27) of the crane system (8) dependent upon the positions of the markers (14, 15, 18, 19).

2. The method as claimed in claim 1,
characterized in that the camera system (9, 10, 11, 12) is moved during the generation of the at least one image data stream along a longitudinal direction (29) of a transport vehicle (30); and
the position of the first marker (14, 18) is determined by the computer unit (13) dependent upon a first momentary position of the camera system (9, 10, 11, 12) when the first marker (14, 18) has been recognized; and
the position of the second marker (15, 19) is determined by the computer unit (13) dependent upon a second momentary

position of the camera system (9, 10, 11, 12) when the second marker (15, 19) has been recognized.

3. The method as claimed in claim 2, characterized in that a first image data stream is generated by a first camera (9) of the camera system (9, 10, 11, 12) arranged at a first end of the lifting device (27); the first image data stream is analyzed by the computer unit (13) making use of the neural network; the first marker (14, 15) is recognized by the computer unit (13) on the basis of the analysis of the first image data stream; and the first momentary position corresponds to a momentary position of the first camera (9).

4. The method as claimed in claim 3, characterized in that a second image data stream is generated by a second camera (10) of the camera system (9, 10, 11, 12) arranged at a second end of the lifting device (27) opposite to the first end; the second image data stream is analyzed by the computer unit (13) making use of the neural network; the second marker (15, 19) is recognized by the computer unit (13) on the basis of the analysis of the second image data stream; and the second momentary position corresponds to a momentary position of the second camera (10).

5. The method as claimed in one of claims 2 to 4, characterized in that, on the basis of the analysis of the at least one image data stream, making use of the neural network: a buffer (14) and/or a load fixing means (18) of the transport vehicle (30) is recognized as the first marker (14, 18); and

a further buffer (15) and/or a further load fixing means (19) of the transport vehicle (30) is recognized as the second marker (15, 19).

6. The method as claimed in one of claims 1 to 5, characterized in that the position of the first marker (15, 19) is determined by the computer unit (13) dependent upon an arrangement of the first marker (14, 18) in the first single image (22); and the position of the second marker (15, 19) is determined by the computer unit (13) dependent upon an arrangement of the second marker (15, 19) in the second single image (23).

7. The method as claimed in one of claims 1 to 6, characterized in that, on the basis of the positions of the markers (14, 15, 18, 19) by the computer unit (13), a spacing of the markers (14, 15, 18, 19) from one another is determined; and the load (28) is loaded by the lifting device (27) dependent upon the spacing.

8. The method as claimed in one of claims 1 to 7, characterized in that at least one operating parameter of the lifting device (27) or the crane system (8) is set dependent upon the positions of the markers (14, 15, 18, 19) by a control system (26) of the crane system (8) in order to load the load (28) automatically.

9. A crane system for loading a load (28), characterized in that the crane system (8) has a camera system (9, 10, 11, 12) which is configured to generate at least one image data stream;

the crane system has a computer unit (13) with an artificial neural network, the computer unit (13) is configured to analyze the at least one image data stream making use of the neural network;

the computer unit (13) is configured, on the basis of the analysis, to recognize a first marker (14, 18) in a first single image (22) of the at least one image data stream and a second marker (15, 19) in a second single image (23) of the at least one image data stream;

the computer unit (13) is configured to determine a position of the first marker (14, 18) and a position of the second marker (15, 19); and

the crane system (8) has a control system (26) which is configured to drive a lifting device (27) of the crane system (8) dependent upon the positions of the markers (14, 15, 18, 19) in order to load the load (28) automatically.

10. The crane system as claimed in claim 9, characterized in that the control system (26) is configured to move the camera system (9, 10, 11, 12) during the generation of the at least one image data stream along a longitudinal direction (29) of a transport vehicle (30); and

the computer unit (13) is configured to determine the position of the first marker (14, 18) dependent upon a first momentary position of the camera system (9, 10, 11, 12) when the first marker (14, 18) has been recognized; and

the computer unit (13) is configured to determine the position of the second marker (15, 19) dependent upon a second momentary position of the camera system (9, 10, 11, 12) when the second marker (15, 19) has been recognized.

11. The crane system as claimed in claim 10,

characterized in that the camera system (9, 10, 11, 12) has a first camera (9) arranged at a first end of the lifting device (27) in order to generate a first image data stream; the computer unit (13) is configured to analyze the first image data stream making use of the neural network; the computer unit (13) is configured to recognize the first marker (14, 18) on the basis of the analysis of the first image data stream; and the first momentary position corresponds to a momentary position of the first camera (9).

12. The crane system as claimed in claim 11, characterized in that the camera system (9, 10, 11, 12) has a second camera (10) arranged at a second end of the lifting device (27) opposite to the first end in order to generate a second image data stream; the computer unit (13) is configured to analyze the second image data stream making use of the neural network; the computer unit (13) is configured to recognize the second marker (15, 19) on the basis of the analysis of the second image data stream; and the second momentary position corresponds to a momentary position of the second camera (10).

13. The crane system as claimed in claim 12, characterized in that the camera system (9, 10, 11, 12) has a third camera (11) arranged at the first end of the lifting device, in order to generate a third image data stream, and a fourth camera (12) arranged at the second end of the lifting device, in order to generate a fourth image data stream; the computer unit (13) is configured to analyze the third and the fourth image data stream making use of the neural network;

the computer unit (13) is configured, on the basis of the analysis of the third image data stream, to recognize a third marker (16, 20) in a third single image (24) of the third image data stream and, on the basis of the analysis of the fourth image data stream, to recognize a fourth marker (17, 21) in a fourth single image (25) of the fourth image data stream;

the computer unit (13) is configured to determine a position of the third marker (16, 20) dependent upon a third momentary position of the third camera (11) when the third marker (16, 20) has been recognized and to determine a position of the fourth marker (17, 21) dependent upon a fourth momentary position of the fourth camera (12) when the fourth marker (17, 21) has been recognized; and

the control system (26) is configured to drive the lifting device (27) of the crane system (8) dependent upon the positions of the third and fourth markers (16, 17, 20, 21) in order to load the load (28) automatically.

14. The crane system as claimed in one of claims 12 or 13, characterized in that the lifting device (27) has a substantially rectangular base shape; and the first and second cameras (9, 10) are arranged at corners of the rectangular base shape.

15. A computer program with commands which, on execution of the computer program by a crane system (8) as claimed in one of the claims 9 to 14, cause the crane system (8) to carry out a method as claimed in one of claims 1 to 8.