SUPPORTING STABILITY OF CIVIL ENGINEERING MACHINE

TECHNICAL FIELD

[0001] The present invention relates to using load capacity for supporting stability of a civil engineering machine.

BACKGROUND

[0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] Solutions for operational safety of a civil engineering machine provide that injuries to personnel and damage to the civil engineering machine can be avoided. Operational safety of the civil engineering machine may be supported by limiting actuation of actuating units of the civil engineering machine. For example, tilting of a civil engineering machine can be avoided during use by limiting actuation of a leader to a distance from a carriage part of the civil engineering machine. However, available load capacity of the civil engineering machine may vary depending on inclination of the ground. Therefore, the available load capacity of the civil engineering machine may be higher at one inclination of the ground than at another inclination of the ground. The available load capacity can also be dependent on a slewing angle the civil engineering machine. The slewing angle indicates the angle of rotation of a structure, such as an upper carriage or a boom, installed to a lower carriage of the civil engineering machine to be rotatable with respect to the lower carriage. Limiting actuation of the actuation units can therefore leave a significant amount of available load capacity of the civil engineering machine unused.

SUMMARY

[0004] According to a first aspect, there is provided a method for a civil engineering machine, including: receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil

engineering machine; receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; controlling at least one operation of the civil engineering machine based on the determined available load capacity; determining, if the load capacity model is valid; displaying by a user interface of the civil engineering machine information indicating the load capacity model; and if an acknowledgement of a user for validating the load capacity model is received, applying the load capacity model for determining the available load capacity of the civil engineering machine.

[0004a] According to a second aspect, there is provided a method for a civil engineering machine, including: receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine ; receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units;

or one or more sensors; applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; controlling at least one operation of the civil engineering machine based on the determined available load capacity; determining an acceleration of a change of the determined available load capacity; and controlling the at least one operation of the civil engineering machine based on the acceleration meeting at least one threshold for the acceleration.

[0004b] According to a third aspect, there is provided a method for a civil engineering machine, including:receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; controlling at least one operation of the civil engineering machine based on the determined available load capacity; the method including at least one of the following: determining an actuation speed of the one or more actuating units of the civil engineering machine or determining a ground speed for driving the civil engineering machine; or determining a rotational speed for rotating an upper carriage of the civil engineering machine with respect to a lower carriage of the civil engineering machine;

or determining a speed for driving at least one leader of the civil engineering machine at a distance from a carriage part of the civil engineering machine based on the determined available load capacity; or determining speed for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine based on the determined available load capacity.

[0004c] According to a fourth aspect, there is provided a method for a civil engineering machine, including:receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; controlling at least one operation of the civil engineering machine based on the determined available load capacity; highlighting on a user interface of the civil engineering machine a load capacity limit that is closest to a center of gravity of the civil engineering machine.

[0004d] According to a fifth aspect, there is provided a civil engineering machine including: means for receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; means for determining a load capacity model of the civil engineering machine

based on the received first inclination measurements and based on the received first load measurements; means for receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; means for applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; means for determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; means for controlling at least one operation of the civil engineering machine based on the determined available load capacity; means for determining, if the load capacity model is valid; means for displaying by a user interface of the civil engineering machine information indicating the load capacity model; and means for, if an acknowledgement of a user for validating the load capacity model is received, applying the load capacity model for determining the available load capacity of the civil engineering machine.

[0004e] According to a sixth aspect, there is provided a civil engineering machine including: means for receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; means for determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; means for receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; means for applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; means for determining

an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; means for controlling at least one operation of the civil engineering machine based on the determined available load capacity; means for determining an acceleration of a change of the determined available load capacity; and means for controlling the at least one operation of the civil engineering machine based on the acceleration meeting at least one threshold for the acceleration.

[0004f] According to a seventh aspect, there is provided a civil engineering machine including:means for receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; means for determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; means for receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; means for applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; means for determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; means for controlling at least one operation of the civil engineering machine based on the determined available load capacity; the civil engineering machine including at least one of the following: means for determining an actuation speed of the one or more actuating units of the civil engineering machine; ormeans for determining a ground speed for driving the civil engineering machine; or means for determining a rotational speed for rotating an upper carriage of the civil engineering machine with respect to a lower carriage of the civil engineering machine; or means for determining a speed for driving

at least one leader of the civil engineering machine at a distance from a carriage part of the civil engineering machine based on the determined available load capacity; or means for determining speed for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine based on the determined available load capacity.

[0004g] According to an eighth aspect, there is provided a civil engineering machine including: means for receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors; means for determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements; means for receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine; means for receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors; means for applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements; means for determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model; means for controlling at least one operation of the civil engineering machine based on the determined available load capacity; means for highlighting on a user interface of the civil engineering machine a load capacity limit that is closest to a center of gravity of the civil engineering machine.

[0004h] According to a ninth aspect, there is provided a civil engineering machine including a memory stored with computer program code thereon, wherein the at least one memory and the computer program code are configured, with at least one processor of the civil engineering machine, to cause the civil engineering machine to perform any of the above aspects.

[0004i] According to a tenth aspect, there is provided a computer program product including computer program code that when executed by processors of a civil engineering machine causes the civil engineering machine to perform any of the above aspects.

[0005] Now, an improved method and technical equipment implementing the method has been invented, by which at least part of the above problems are alleviated. Various aspects disclosed herein include a method, an apparatus, a computer program and a non-transitory computer readable medium.

[0006] The embodiments and features, if any, described in this specification that do not fall under the scope of the above aspects are to be interpreted as examples useful for understanding various embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a more complete understanding of the example embodiments, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

FIG. 1 illustrates an example of a civil engineering machine in accordance with at least some embodiments;

FIG. 2 illustrates a block diagram of a civil engineering machine in accordance with at least some embodiments;

FIG. 3 is illustrates an example of a method for a civil engineering machine in accordance with at least some embodiments;

Fig. 4 illustrates an example of a method for controlling a civil engineering machine in accordance with at least some embodiments;

Fig. 5 and Fig. 6 illustrate examples of available capacities of a civil engineering machine based on a distance of a center of gravity to load capacity limits;

Fig. 7 illustrates an example of a method for supporting continued use of a load capacity model between instances of use of a civil engineering machine in accordance with at least some embodiments;

Fig. 8 illustrates an example of a method for supporting an up-to-date load capacity model at a civil engineering machine in accordance with at least some embodiments;

Fig. 9 illustrates load measurements of a civil engineering machine in accordance with at least some embodiments;

Fig. 10 illustrates examples of configurations and corresponding load capacity models of the civil engineering machine in accordance with at least some embodiments;