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System and method for monitoring work area

Abstract

A system for monitoring a work area of a work machine includes a sensor system. The sensor system generates one or more input signals corresponding to a position of at least one object present in at least one of the work area and a predetermined area. The input signals are indicative of the position of the object at different instances of time. The system also includes a controller communicably coupled to the sensor system. The controller includes one or more memories and one or more processors. The one or more processors receive the one or more input signals, determine a moving route of the object based on the receipt of the one or more input signals, and generate a response signal if a start point of the object is located in the predetermined area and an end point of the object is located at the work area.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates to a system and a method for monitoring a work area of a work machine.

BACKGROUND

(2) A work machine, such as, an excavator is often used to perform a variety of tasks at a worksite. For example, one or more work machines may be used to remove a layer of gravel, concrete, asphalt, soil, or other material at a work area of the worksite.

(3) During a work operation, such as digging, one or more objects may slip or enter into the work area. For example, the one or more objects may include a safety cone, one or more tools, and the like. It is imperative to determine if the object is from within the work area or if the object is a foreign object which may have moved into the work area. If the object is from within the work area, the work operation may be continued. However, if the object has entered into the work area, the work operation may have to be paused in order to remove the object from the work area.

(4) Typically, a classification algorithm is used to identify if one or more objects have entered the work area. However, the classification algorithm may lack accuracy in identification of the objects, and may not be reliable. Further, the classification algorithm typically requires large amounts of computational power to classify/identify the objects at the work area. Moreover, classifying objects using the classification algorithm may require picky sampling techniques which may be costly and may have low performance. Thus, such a classification algorithm may not be practical and cost effective.

(5) In some cases, a supervisor may have to continuously monitor the work area to check any possible entrance of the objects into the work area, which may not be feasible as such a technique may subject supervisors to harsh operating environments at the worksite and may also increase human interference.
(6) U.S. Pat. No. 11,126,188 describes a method for maintaining a work surface at a worksite. The method includes receiving a worksite plan to be executed by a machine at a worksite and determining first travel parameters of the machine. Such first travel parameters include a first travel path along a work surface, and first work tool positions. The method also includes controlling the machine to traverse at least part of the first travel path, receiving sensor information associated with the work surface, and identifying an imperfection of the work surface located along the first travel path. The method further includes determining second travel parameters of the machine. Such second travel parameters including a second travel path along the work surface, and second work tool positions. The method also includes controlling the machine to traverse at least part of the second travel path while positioning the work tool according to at least one of the second work tool positions.
SUMMARY OF THE DISCLOSURE
(7) In an aspect of the present disclosure, a system for monitoring a work area of a work machine is provided. The system includes a sensor system configured to generate a plurality of input signals corresponding to a position of at least one object present in at least one of the work area and a predetermined area surrounding the work area. The plurality of input signals are indicative of the position of the object at different instances of time. The system also includes a controller communicably coupled to the sensor system. The controller includes one or more memories and one or more processors communicably coupled with the one or more memories. The one or more processors are configured to receive the plurality of input signals indicative of the position of the object at different instances of time. The one or more processors are also configured to determine a moving route of the object based on the receipt of the plurality of input signals. The moving route includes a start point and an end point. The one or more processors are further configured to generate a response signal if the start point of the object is located in the predetermined area and the end point of the object is located at the work area.
(8) In another aspect of the present disclosure, a method for monitoring a work area of a work machine is provided. The method includes generating, by a sensor system, a plurality of input signals corresponding to a position of at least one object present in at least one of the work area and a predetermined area surrounding the work area. The plurality of input signals are indicative of the position of the object at different instances of time. The method also includes receiving, by a controller, the plurality of input signals indicative of the position of the object at different instances of time. The method further includes determining, by the controller, a moving route of the object based on the receipt of the plurality of input signals. The moving route includes a start point and an end point. The method includes generating, by the controller, a response signal if the start point of the object is located in the predetermined area and the end point of the object is located at the work area.
(9) Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a schematic diagram illustrating a portion of a worksite including a work area and a work machine, according to an embodiment of the present disclosure;
(2) FIG. **2** is a block diagram of a system for monitoring the work area of the work machine shown

in FIG. **1**, according to an embodiment of the present disclosure; and

(3) FIG. **3** is a flowchart for a method for monitoring the work area of the work machine, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

(4) Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

(5) Referring to FIG. **1**, a schematic view of a portion of a worksite **100** including a work machine **104** is illustrated. The worksite **100** includes a work area **102** and a predetermined area **132** surrounding the work area **102**. The predetermined area **132** is a virtual boundary defined around the work area **102**. The predetermined area **132** may be larger than the work area **102**. The work machine **104** may perform various earthmoving operations, for example a digging operation, at the work area **102**.

(6) The work machine **104** is embodied as a hydraulic excavator that may be used for purposes, such as, digging, construction, landscaping, and the like. Alternatively, the work machine **104** may be embodied as an off-highway truck, a dozer, a wheel loader, a track-type tractor, a motor grader, and the like, that may be used in various industries to move, remove, or load materials, such as, asphalt, debris, dirt, snow, feed, gravel, logs, raw minerals, recycled material, rock, sand, and/or woodchips. In the illustrated example of FIG. **1**, the work machine **104** is shown as performing the digging operation at the work area **102**. In the illustrated example of FIG. **1**, the work machine **104** is embodied as an autonomous work machine. Alternatively, the work machine **104** may embody a semi-autonomous work machine or a manual work machine.

(7) The work machine **104** includes a front work unit **106**. The work machine **104** also includes a body **108**. The front work unit **106** is movably coupled to the body **108**. The front work unit **106** includes a boom **110** and an arm **112**. The front work unit **106** also includes a work tool **114** pivotally coupled to the arm **112**. The work tool **114** may be used to perform work operations, such as, loading, stock piling, dumping, digging, and the like. The work tool **114** is embodied as a bucket herein. Alternatively, the work tool **114** may include any other type of work tool known in the art, such as, a blade.

(8) The body **108** includes an operator cabin **116**. The operator cabin **116** may include one or more controls (not shown) that may enable an operator to control the work machine **104**. The body **108** also includes a hood **118**. Further, the work machine **104** includes a power source (not shown) disposed within the hood **118**. The power source may include an engine, such as, an internal combustion engine, batteries, motors, and the like. The power source may provide power to various components of the work machine **104** for operational and mobility requirements. The work machine **104** includes a pair of tracks **120**. The pair of tracks **120** provide support and mobility to the work machine **104** on grounds. Alternatively, the work machine **104** may include wheels instead of the tracks **120**.

(9) Further, one or more objects, such as, an object **130** may be present at the worksite **100**. In some examples, the object **130** may be present at the work area **102** before a commencement of the digging operation. However, in other examples, as shown in FIG. **1**, the object **130** may be present in the predetermined area **132**, and may move into the work area **102**, for example, due to operations being performed at the worksite **100**. In the illustrated example of FIG. **1**, the single object **130** i.e., a safety cone is shown at the worksite **100**. However, a number of objects, such as, helmets, tools, basketballs, and the like may be present at the work area **102** and/or the predetermined area **132**.

(10) Further, it is desired to determine if the object **130** is from within the work area **102** or if the object **130** has moved into the work area **102** after the commencement of the digging operation. For example, if the object **130** moves to the work area **102** after the commencement of the digging operation, the digging operation may have to be stopped for removal of the object **130** from the work area **102**. Accordingly, the present disclosure relates to a system **122** (shown in FIG. **2**) for

monitoring the work area **102**. The system **122** determines if the object **130** belongs to the work area **102** or if the object **130** has moved into the work area **102** after the commencement of the digging operation.

(11) FIG. **2** illustrates a block diagram of the system **122** for monitoring the work area **102** of the work machine **104** shown in FIG. **1**, according to an example of the present disclosure. The system **122** includes a sensor system **124**. The sensor system **124** is mounted on the work machine **104** and/or the worksite **100** (see FIG. **1**) at which the work machine **104** is operating.

(12) The sensor system **124** generates one or more input signals **128** corresponding to a position of the one or more objects **130** (see FIG. **1**) present at the work area **102** and/or the predetermined area **132** surrounding the work area **102**. The one or more input signals **128** are indicative of the position of the object **130** at different instances of time. For example, the sensor system **124** may generate a first input signal at a first instance of time, a second input signal at a second instance of time, and so on. It should be noted that the first input signal may correspond to the second input signal if the object **130** has not moved.

(13) Further, the sensor system **124** includes a number of sensing devices **126**. Particularly, the sensor system **124** includes one or more of an imaging device, a laser imaging, detection, and ranging (LIDAR) sensor, a radio detection and ranging (RADAR) sensor, an infrared sensor, a global positioning system (GPS) sensor, and an ultrasonic sensor. In some examples, the number of sensing devices **126** may be mounted on the work machine **104** or the worksite **100**. In other examples, the number of sensing devices **126** may be mounted on the work machine **104** as well as the worksite **100**, so that the sensing devices **126** together cover a 360 degrees view of the work area **102** and/or the predetermined area **132**.

(14) The number of sensing devices **126** generate the one or more input signals **128** indicative of the position of the object **130**. Further, in one example, each input signal **128** may include a co-ordinate of the object **130** at the work area **102** and/or the predetermined area **132**. The co-ordinates may be received from the GPS sensor. However, the input signals **128** may include any other parameter that may allow tracking of the object **130** at the work area **102** and/or the predetermined area **132**.

(15) The system **122** also includes a controller **134** communicably coupled to the sensor system **124**. In an application, the controller **134** may be a control circuit, a computer, a microprocessor, a microcomputer, a central processing unit, or any suitable device or apparatus. In some cases, the controller **134** may include one or more of a digital circuit designed to process information, an analog circuit designed to process information, and/or other mechanisms for electronically processing information.

(16) The controller **134** includes one or more memories **136** and one or more processors **138** communicably coupled with the one or more memories **136**. In some examples, the one or more memories **136** may include a random access memory (RAM) such as a synchronous dynamic random access memory (SDRAM), read-only memory (ROM), a non-volatile random access memory (NVRAM), an electrically erasable programmable read-only memory (EEPROM), a flash memory, a magnetic or optical data storage media, and the like that can be used to store desired program codes in the form of instructions or data structures and that can be accessed by the processors **138**. In some examples, the processors **138** may embody digital processors or analog processors.

(17) With reference to FIGS. **1** and **2**, the processors **138** receive the input signals **128** indicative of the position of the object **130** at different instances of time. In some examples, the processors **138** may start receiving the input signals **128** as soon as the work machine **104** starts operating. Further, the processors **138** determine a moving route **140** of the object **130** based on the receipt of the input signals **128**. The moving route **140** includes a start point **142** and an end point **144**. In the illustrated example of FIG. **1**, the start point **142** is a position of the object **130** at the predetermined area **132** at a time T**1** and the end point **144** is a position of the object **130** at the work area **102** at a time T**2**.

It should be noted that the processors **138** may determine the moving routes of each object present at the work area **102** and the predetermined area **132**.
(18) In order to determine the moving route **140**, the processors **138** analyze the input signals **128** received from the number of sensing devices **126**. Further, the processors **138** may determine if the input signals **128** received from two or more sensing devices **126** correspond to the same object **130** to determine the moving route **140** of the object **130**. In some examples, the processors **138** determine the moving route **140** of the object **130** based on one or more of feature tracking, a distance of the object **130** relative to the sensor system **124**, and a location of the object **130** relative to the sensor system **124**. More particularly, in one example, the processors **138** may determine if the input signals **128** received from two or more sensing devices **126** correspond to the same object **130** to determine the moving route **140** based on the feature tracking. For example, the processors **138** may determine if objects present in a view of different sensing devices **126** have a same circular feature, a same triangular feature, a same rectangular feature, and the like to determine in the input signals **128** received from two or more sensing devices **126** correspond to the same object **130**.
(19) In another example, the processors **138** may determine if the input signals **128** received from two or more sensing devices **126** correspond to the same object **130** to determine the moving route **140** based on the distance and/or the location of the object **130**. For example, the processors **138** may use rules, such as, distance/location proximation to determine if the input signals **128** received from two or more sensing devices **126** correspond to the same object **130**. This step may be directly achieved by geometry transformation based on mounting angles and locations of the sensing devices **126**.
(20) Further, the processors **138** generate a response signal **146** if the start point **142** of the object **130** is located at the predetermined area **132** and the end point **144** of the object **130** is located at the work area **102**. In some examples, the processors **138** track the movement of the object **130** from the predetermined area **132** into the work area **102** to generate the response signal **146**. In one example, the response signal **146** is a control signal to halt the earthmoving operation by the work machine **104**. In some examples, the response signal **146** may be directly transmitted to the front work unit **106** to halt the digging operation. In other examples, the system **122** may be communicably coupled to a machine control unit (MCU). In such an example, the response signal **146** may be transmitted to the MCU, so that the MCU may in turn transmit control signals to the front work unit **106** to halt the digging operation.
(21) In another example, the response signal **146** is an alert notification displayed on a display device **148** present in the operator cabin **116** of the work machine **104** and/or a remotely located back-office **150**. The display device **148** may include a user interface that may be present in the operator cabin **116** or the back-office **150**. In an example, when the work machine **104** is embodied as a semi-autonomous machine, the alert notification may be displayed on the display device **148** present in the operator cabin **116** so that the operator may take corrective actions, such as, halting of the earthmoving operation if the object **130** has moved from outside of the work area **102**. Further, when the work machine **104** is embodied as an autonomous machine, the alert notification may be displayed on the display device **148** present in the back-office **150** so that a personnel may take corrective actions, such as, halting of the earthmoving operation. In the example illustrated in FIG. **2**, the display device **148** is positioned at the back-office **150**. Further, the alert notification may include a visual notification, such as, a text message or one or more icons presented on the display device **148**. In another example, the alert notification may be an audible notification, such as, a buzzer or an audible message. The alert notification may also include flashing of lights, or any other mode of notifying operators/personnel regarding the presence of the object **130**.
(22) It is to be understood that individual features shown or described for one embodiment may be combined with individual features shown or described for another embodiment. The above described implementation does not in any way limit the scope of the present disclosure. Therefore,

it is to be understood although some features are shown or described to illustrate the use of the present disclosure in the context of functional segments, such features may be omitted from the scope of the present disclosure without departing from the spirit of the present disclosure as defined in the appended claims.

INDUSTRIAL APPLICABILITY

(23) The system **122** for monitoring the work area **102** of the work machine **104** as described herein includes the sensor system **124**. The sensor system **124** determines if one or more objects, such as, the object **130** is from within the work area **102** or the object has entered the work area **102** from the predetermined area **132**. The system **122** uses motion detection and tracking techniques to determine the moving route **140** of the object **130**. If the system **122** determines that the object **130** has moved into the work area **102** from the predetermined area **132**, the system **122** generates the response signal **146** to indicate that the object **130** is not from the work area **102**. The response signal **146** may include the control signal that may halt the earthmoving operation so that the object **130** may be removed from the work area **102**. Alternatively, the response signal **146** may include the alert notification that may alert the operator/personnel regarding the movement of the object **130** into the work area **102**. Based on the alert notification, the operator/personnel may take corrective measures, for example, removal of the object **130** from the work area **102**.

(24) The system **122** may result in improvement in a detection time of the object **130**, as well as increase a confidence and accuracy with which the work area **102** is monitored. The system **122** provides an automated technique of monitoring the work area **102**, which may reduce dependence on human efforts. Further, the system **122** provides a cost-effective approach with low response latency. Specifically, the sensing devices **126** that are used for detecting the movement of the object **130** are cost-effective, which may reduce an overall cost associated with the system **122**. Further, the system **122** does not require large amounts of computational power as the system **122** eliminates usage of any object classification algorithms to detect a nature/type of the object **130** and simply determines if the object **130** belongs to the work area **102** based on motion detection and tracking of the object **130**.

(25) Referring to FIG. **3**, a flowchart for a method **300** for monitoring the work area **102** of the work machine **104** is illustrated. At step **302**, the one or more input signals **128** corresponding to the position of the one or more objects **130** present at the work area **102** and/or the predetermined area **132** surrounding the work area **102** are generated by the sensor system **124**. The one or more input signals **128** are indicative of the position of the object **130** at different instances of time. The sensor system **124** is mounted on the work machine **104** and/or the worksite **100** at which the work machine **104** is operating. The sensor system **124** includes the number of sensing devices **126**. The sensor system **124** includes one or more of the imaging device, the LIDAR sensor, the RADAR sensor, the GPS sensor, the infrared sensor, and the ultrasonic sensor. The number of sensing devices **126** generate the one or more input signals **128** indicative of the position of the object **130**. Each input signal **128** includes the co-ordinate of the object **130** in the work area **102** and/or the predetermined area **132**.

(26) At step **304**, the one or more input signals **128** indicative of the position of the object **130** at different instances of time are received by the controller **134**. The controller **134** analyzes the input signals **128** received from two or more of the sensing devices **126**. Further, the controller **134** determines if the input signal **128** received from two or more of the sensing devices **126** corresponds to the same object **130**.

(27) At step **306**, the moving route **140** of the object **130** is determined by the controller **134** based on the receipt of the one or more input signals **128**. The moving route **140** includes the start point **142** and the end point **144**. The controller **134** determines the moving route **140** of the object **130** based on the feature tracking, the distance of the object **130** relative to the sensor system **124**, and/or the location of the object **130** relative to the sensor system **124**.

(28) At step **308**, the response signal **146** is generated by the controller **134** if the start point **142** of

the object **130** is located at the predetermined area **132** and the end point **144** of the object **130** is located at the work area **102**. The controller **134** tracks the movement of the object **130** from the predetermined area **132** into the work area **102** to generate the response signal **146**. In an example, the response signal **146** is generated to halt the earthmoving operation by the work machine **104**. In another example, the response signal **146** is generated to display the alert notification on the display device **148** present in the operator cabin **116** of the work machine **104** and/or the remotely located back-office **150**.

(29) While aspects of the present disclosure have been particularly shown and described with reference to the embodiments above, it will be understood by those skilled in the art that various additional embodiments may be contemplated by the modification of the disclosed machine, systems and methods without departing from the spirit and scope of the disclosure. Such embodiments should be understood to fall within the scope of the present disclosure as determined based upon the claims and any equivalents thereof.

Claims

1. A system for monitoring a work area of a work machine, the system comprising: a sensor system configured to generate a plurality of input signals corresponding to a position of at least one object present in at least one of the work area and a predetermined area surrounding the work area, wherein the plurality of input signals are indicative of the position of the object at different instances of time; and a controller communicably coupled to the sensor system, wherein the controller includes one or more memories and one or more processors communicably coupled with the one or more memories, and wherein the one or more processors are configured to: receive the plurality of input signals indicative of the position of the object at different instances of time; determine a moving route of the object based on the plurality of input signals, wherein the moving route includes a start point and an end point; and generate a response signal if in response to a determination that the start point of the object is located in the predetermined area and the end point of the object is located at the work area; and wherein the response signal comprises at least one of: (i) a first electronic instruction to cause a machine control unit (MCU), communicatively coupled to the controller, to halt operation of the work machine, or (ii) a second electronic instruction to cause a display device to display an alert notification.
2. The system of claim 1, wherein the sensor system includes a plurality of sensing devices, the plurality of sensing devices being configured to generate one or more input signals indicative of the position of the object.
3. The system of claim 2, wherein the one or more processors are further configured to: analyze the input signal received from two or more of the plurality of sensing devices; and determine if the input signal received from two or more of the plurality of sensing devices corresponds to a same object to determine the moving route of the object.
4. The system of claim 1, wherein the one or more processors are further configured to determine the moving route of the object based on at least one of feature tracking, a distance of the object relative to the sensor system, or a location of the object relative to the sensor system.
5. The system of claim 1, wherein each input signal includes a co-ordinate of the object in at least one of the work area and the predetermined area.
6. The system of claim 1, wherein the display device is disposed in at least one of an operator cabin of the machine or a remotely located back-office.
7. The system of claim 1, wherein the sensor system includes at least one of an imaging device, a laser imaging, detection, and ranging (LIDAR) sensor, a radio detection and ranging (RADAR) sensor, an infrared sensor, a global positioning system (GPS) sensor, and an ultrasonic sensor.
8. The system of claim 1, wherein the sensor system is mounted on at least one of the work machine and a worksite at which the work machine is operating.

9. The system of claim 1, wherein the one or more processors are further configured to track a movement of the object from the predetermined area into the work area to generate the response signal.
10. A method for monitoring a work area of a work machine, the method comprising: generating, by a sensor system, a plurality of input signals corresponding to a position of at least one object present in at least one of the work area and a predetermined area surrounding the work area, wherein the plurality of input signals are indicative of the position of the object at different instances of time; receiving, by a controller, the plurality of input signals indicative of the position of the object at different instances of time; determining, by the controller, a moving route of the object based on the plurality of input signals, wherein the moving route includes a start point and an end point; generating, by the controller, a response signal if in response to a determination that the start point of the object is located in the predetermined area and the end point of the object is located at the work area; and based on the response signal, performing at least one of: (i) halting, by a machine control unit (MCU), operation of the work machine, or (ii) displaying, by a display device of the work machine, an alert notification.
11. The method of claim 10, wherein the sensor system includes a plurality of sensing devices, the plurality of sensing devices being configured to generate one or more input signals indicative of the position of the object.
12. The method of claim 11 further comprising: analyzing, by the controller, the input signal received from two or more of the plurality of sensing devices; and determining, by the controller, if the input signal received from two or more of the plurality of sensing devices corresponds to a same object.
13. The method of claim 10 further comprising determining, by the controller, the moving route of the object based on at least one of feature tracking, a distance of the object relative to the sensor system, and a location of the object relative to the sensor system.
14. The method of claim 10, wherein each input signal includes a co-ordinate of the object in at least one of the work area and the predetermined area.
15. The method of claim 10 wherein the display device is present in at least one of an operator cabin of the machine and a remotely located back-office.
16. The method of claim 10, wherein the sensor system includes at least one of an imaging device, a laser imaging, detection, and ranging (LIDAR) sensor, a radio detection and ranging (RADAR) sensor, an infrared sensor, a global positioning system (GPS) sensor, and an ultrasonic sensor.
17. The method of claim 10, wherein the sensor system is mounted on at least one of the work machine and a worksite at which the work machine is operating.
18. The method of claim 10 further comprising track, by the controller, a movement of the object from the predetermined area into the work area to generate the response signal.
19. One or more non-transitory, computer-readable media having instructions stored thereon that, when executed by one or more processors of a computing system, perform operations for monitoring a work area of a work machine, the operations comprising: generating, by a sensor system, a plurality of input signals corresponding to a position of at least one object present in at least one of the work area and a predetermined area surrounding the work area, wherein the plurality of input signals are indicative of the position of the object at different instances of time; receiving, by a controller, the plurality of input signals indicative of the position of the object at different instances of time; determining, by the controller, a moving route of the object based on the plurality of input signals, wherein the moving route includes a start point and an end point; generating, by the controller, a response signal in response to a determination that the start point of the object is located in the predetermined area and the end point of the object is located at the work area; and based on the response signal, performing at least one of: (i) causing a machine control unit (MCU) to halt operation of the work machine, or (ii) displaying, by a display device of the work machine, an alert notification.