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(54) SYSTEMS AND METHODS FOR MONITORING AN ELECTRIC VEHICLE CHARGER

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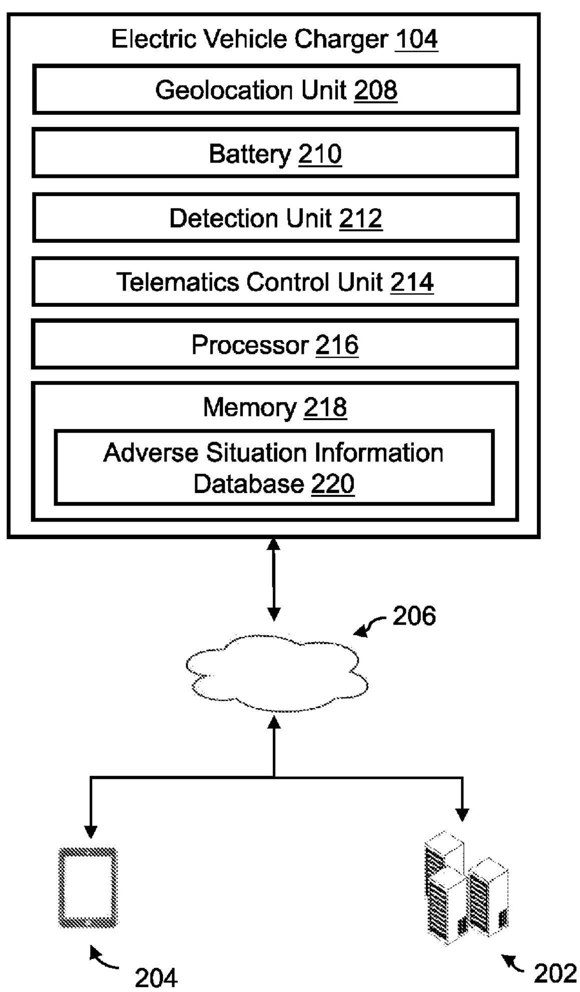
(57) ABSTRACT

A system including a detection unit and a processor is disclosed. The detection unit may be configured to measure a level of nonconforming movement associated with the system. The processor may be configured to determine a system installation state from a plurality of system installation states, and identify an optimal movement threshold, from a plurality of movement thresholds associated with the plurality of system installation states, based on the system installation state. The system may further determine that the level of nonconforming movement may be greater than the optimal movement threshold, and perform a predefined action responsive to determining that the level of nonconforming movement may be greater than the optimal movement threshold.



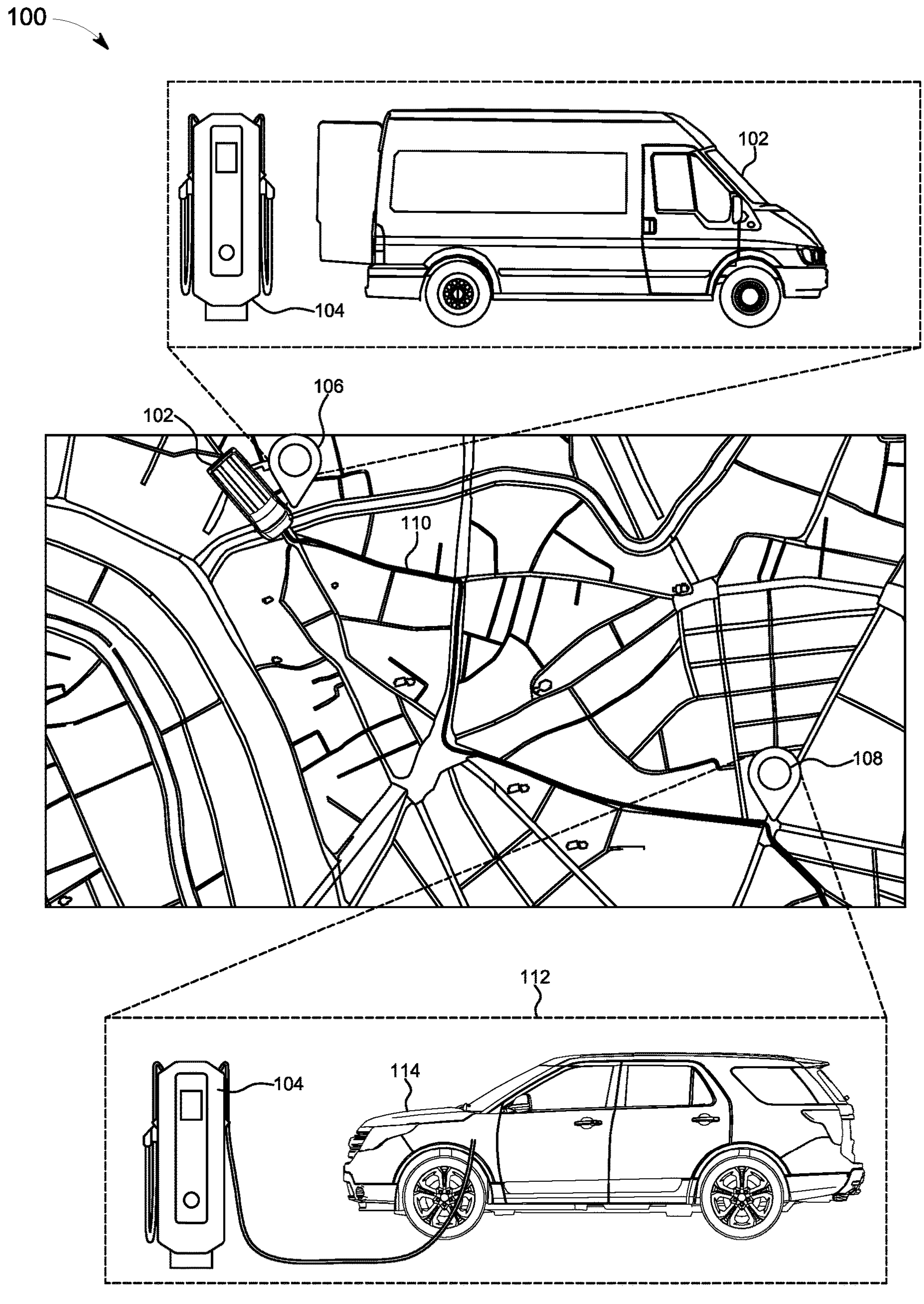


FIG. 1

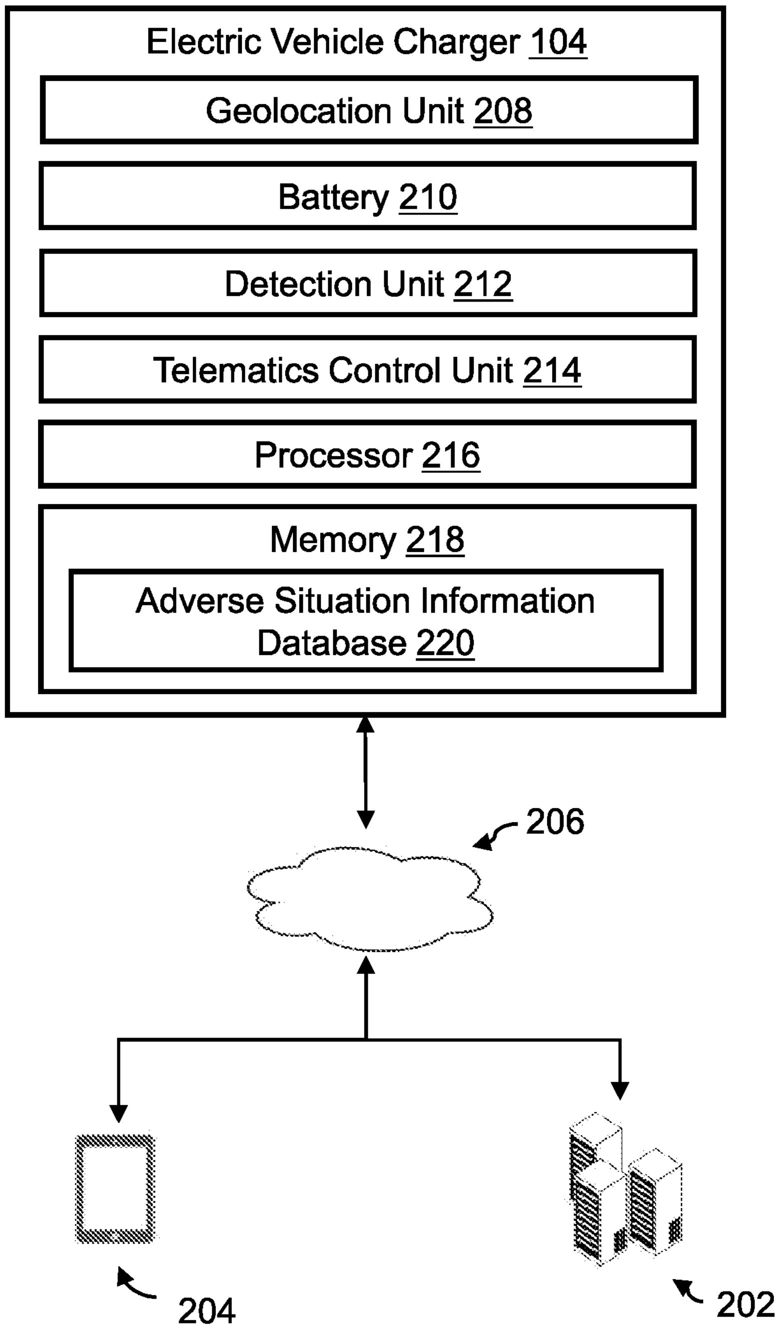

Electric Vehicle Charger 104
Geolocation Unit 208
Battery 210
Detection Unit 212
Telematics Control Unit 214
Processor 216
Memory 218
Adverse Situation Information Database 220
206
204
202

FIG. 2

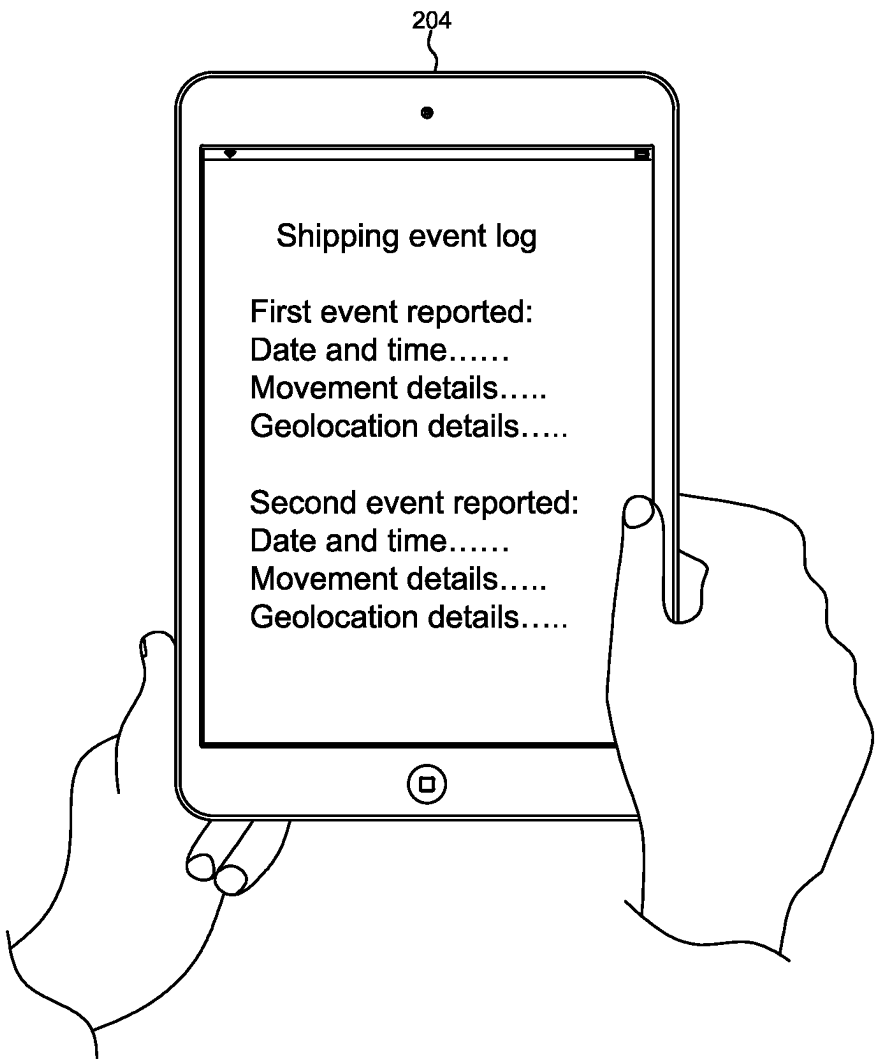

204
Shipping event log
First event reported:
Date and time……
Movement details…..
Geolocation details…..
Second event reported:
Date and time……
Movement details…..
Geolocation details…..

FIG. 3

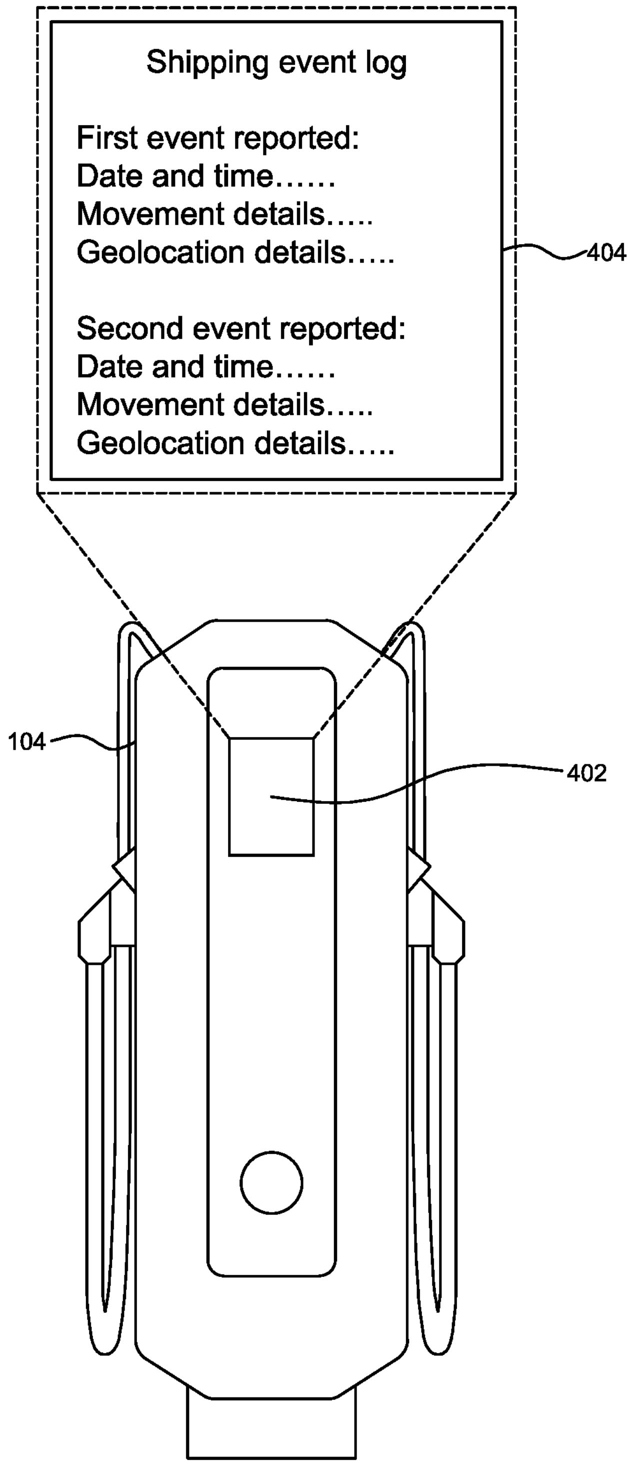

Shipping event log
First event reported:
Date and time……
Movement details…..
Geolocation details…..
Second event reported:
Date and time……
Movement details…..
Geolocation details…..
404
104
402

FIG. 4

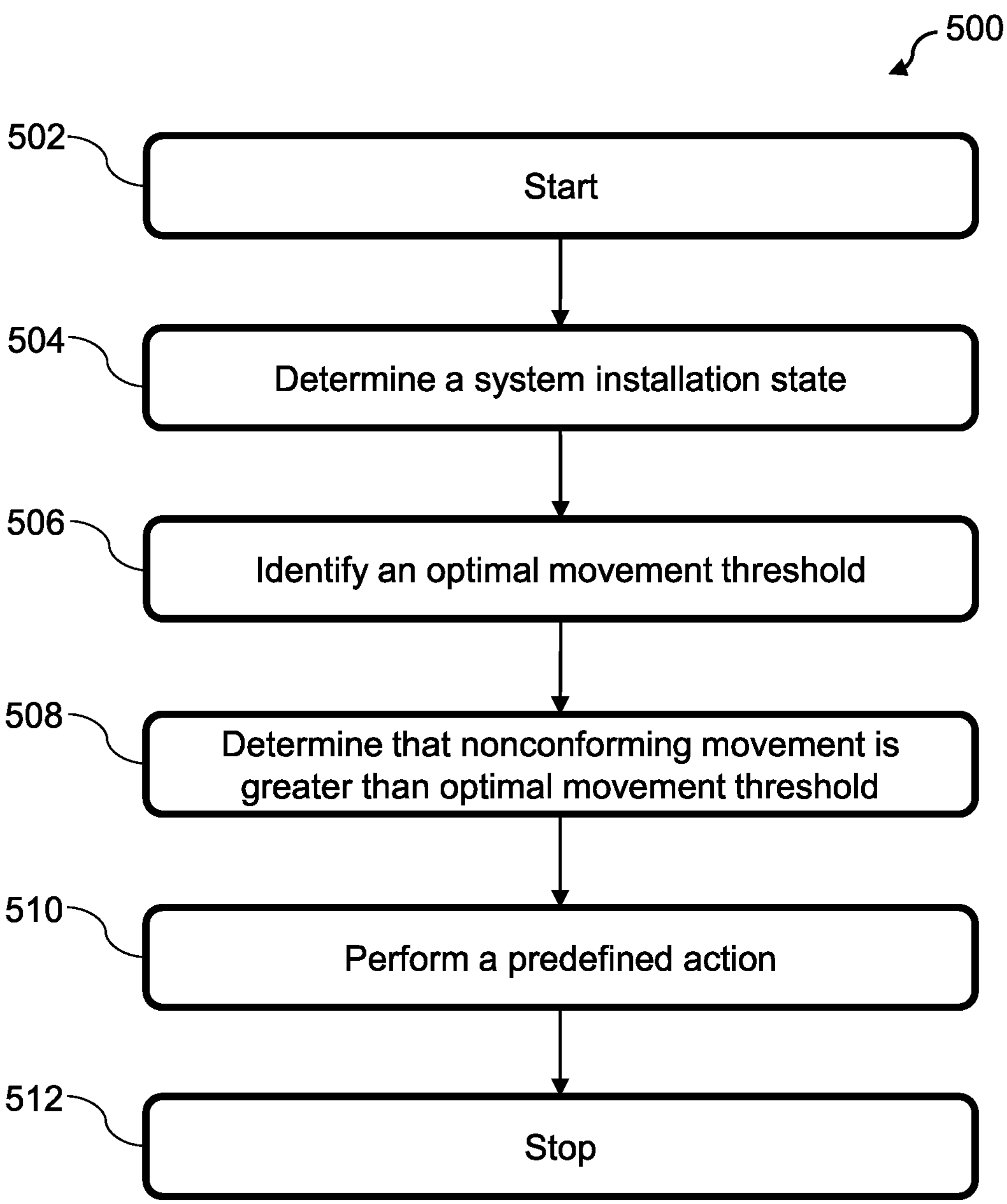

500
502
Start
504
Determine a system installation state
506
Identify an optimal movement threshold
508
Determine that nonconforming movement is greater than optimal movement threshold
510
Perform a predefined action
512
Stop

FIG. 5

SYSTEMS AND METHODS FOR MONITORING AN ELECTRIC VEHICLE CHARGER

FIELD

[0001] The present disclosure relates to systems and methods for monitoring an electrical vehicle charger during shipping, pre-installation stage, and post-installation stage.

BACKGROUND

[0002] Many equipment or systems require transport from their manufacturing sites or warehouses to their installation sites or destination locations. For example, an electric vehicle charger may be required to be transported from a warehouse to a customer's location or a charging station location for installation. There may be instances of an electric charger encountering an adverse situation during the shipping stage and/or the pre-installation stage, resulting in dents, scratches, etc. on the charger and/or one or more broken charger components.

[0003] In such instances, it becomes difficult to ascertain whether the electric charger was shipped in such a state from the warehouse or if the electric charger became broken during the shipping operation and/or the pre-installation stage where the customer may have mishandled the electric charger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The detailed description is set forth with reference to the accompanying drawings. The use of the same reference numerals may indicate similar or identical items. Various embodiments may utilize elements and/or components other than those illustrated in the drawings, and some elements and/or components may not be present in various embodiments. Elements and/or components in the figures are not necessarily drawn to scale. Throughout this disclosure, depending on the context, singular and plural terminology may be used interchangeably.

[0005] FIG. **1** depicts an example environment in which techniques and structures for providing the systems and methods disclosed herein may be implemented.

[0006] FIG. **2** depicts a block diagram of an electric vehicle charger in accordance with the present disclosure.

[0007] FIG. **3** depicts an example snapshot of a user interface displaying a shipping event log in accordance with the present disclosure.

[0008] FIG. **4** depicts an example snapshot of an electric vehicle charger interface displaying a shipping event log in accordance with the present disclosure.

[0009] FIG. **5** depicts a flow diagram of an example method for monitoring an electric vehicle charger in accordance with the present disclosure.

DETAILED DESCRIPTION

Overview

[0010] The present disclosure describes a system or an electric vehicle charger ("charger") that may be configured to determine details/information associated with an adverse situation that may be encountered by the charger. In some aspects, the charger may encounter an adverse situation when the charger may be getting shipped from a warehouse/source location to a customer/destination location, or when the charger may be at the destination location in a pre-installation state or an installed state. The charger may get dents, scratches, etc., and/or one or more charger components may get broken when the charger encounters an adverse situation. The adverse situation details/information determined by the charger may assist the customer and/or an operator associated with a charger transport/shipping firm, a charger original equipment manufacturer (OEM), and an insurance firm, etc. to determine a potential party responsible for the adverse situation and/or plan remedial actions to prevent similar adverse situations in the future.

[0011] In some aspects, the charger may include a detection unit or an accelerometer that may be configured to measure a level of nonconforming or abrupt charger movements, when the charger may be in a transit state (e.g., when the charger may be getting shipped), a pre-installation state, or an installed state. The charger may be further configured to determine an optimal movement threshold associated with the charger that may be considered "normal" or within "permissible limits", based on the charger state in which the charger may be in. For example, the charger may determine a first movement threshold as the optimal movement threshold when the charge state may be the transit state, a second movement threshold as the optimal movement threshold when the charge state may be the pre-installation state, and a third movement threshold as the optimal movement threshold when the charge state may be the installed state.

[0012] Responsive to determining the optimal movement threshold, the charger may compare the level of nonconforming movement measured by the accelerometer with the optimal movement threshold to determine whether the charger may have encountered an adverse situation. In some aspects, the charger may determine that the charger may have encountered an adverse situation when the level of nonconforming measured by the accelerometer may be greater than the optimal movement threshold. Responsive to such determination, the charger may perform one or more predefined actions.

[0013] For example, responsive to determining that the charger may have encountered an adverse situation, the charger may power its telematics control unit (TCU) and a geolocation unit by using the energy stored in a charger battery (e.g., when the charger may be in the transit state or the pre-installation state, or when the charger may be in the installed state but the utility power supply to the charger may be interrupted). When the geolocation unit may be powered-up, the geolocation unit may determine a charger geolocation where the charger may have encountered the adverse situation. Further, when the TCU may be powered-up, the TCU may transmit details associated with the adverse situation to a server and/or a user device. In an exemplary aspect, the details associated with the adverse situation may include the charger geolocation where the charger may have encountered the adverse situation, information associated with date and time when the charger may have encountered the adverse situation, the level of nonconforming movement measured by the accelerometer, and/or the like. The charger may further store the details described above in a charger memory.

[0014] The customer and/or the operator associated with a charger transport/shipping firm, a charger OEM, an insurance firm, etc. may access the server, the user device and/or the charger memory to analyze the details associated with the adverse situation, to ascertain or determine a party potentially responsible for the adverse situation (and plan future remedial actions).

[0015] The present disclosure discloses a charger that may determine details associated with an adverse situation that may be encountered by the charger. The charger may determine the details associated with the adverse situation when the charger may be in transit, a pre-installation state or after installation. The details assist a charger customer and/or an operator associated with a charger OEM, and an insurance firm, etc. to conveniently determine a party responsible for the adverse situation and accordingly plan future actions. The charger provides end-to-end monitoring support to the customer and/or the operator, as the charger determines the details associated with the adverse situation right from the charger's shipping state to the post-installation state. These and other advantages of the present disclosure are provided in detail herein.

Illustrative Embodiments

[0016] The disclosure will be described more fully hereinafter with reference to the accompanying drawings, in which example embodiments of the disclosure are shown, and not intended to be limiting.

[0017] FIG. **1** depicts an example environment **100** in which techniques and structures for providing the systems and methods disclosed herein may be implemented. The environment **100** may include a vehicle **102** that may be configured to transport a system **104** from a source location **106** to a destination location **108** through a road network **110**. The vehicle **102** may take the form of any commercial vehicle such as, for example, a car, a work vehicle, a crossover vehicle, a truck, a van, a minivan, etc. Further, the vehicle **102** may be a manually driven vehicle and/or may be configured to operate in a fully autonomous (e.g., driverless) mode or a partially autonomous mode and may include any powertrain such as, for example, a gasoline engine, one or more electrically-actuated motor(s), a hybrid system, etc.

[0018] In the exemplary aspect depicted in FIG. **1**, the system **104** is an electric vehicle charger; however, the present disclosure is not limited to such an aspect. The system **104** may be any other device/apparatus/equipment that may be required to be transported from the source location **106** to the destination location **108**, without departing from the present disclosure scope. Hereinafter, the system **104** is referred to as charger **104** in the present disclosure.

[0019] The source location **106** may be, for example, a warehouse, a manufacturing plant, a distributor/retailer store, and/or the like, from where the charger **104** may be required to be loaded into the vehicle **102** and transported to the destination location **108**. The destination location **108** may be, for example, a customer home/office, a public or private charging station, and/or the like, from where a customer (not shown) may receive the charger **104** from the vehicle **102** and get the charger **104** installed. An example snapshot of the charger **104** in the installed state is depicted in a view **112** of FIG. **1**. As shown in the view **112**, any electric vehicle (e.g., a vehicle **114**, which may be similar to or different from the vehicle **102**) may get charged at the destination location **108** using the charger **104**, when the charger **104** may be in the installed state.

[0020] A person ordinarily skilled in the art may appreciate that in some cases, the charger **104** may encounter an adverse situation at the source location **106** (e.g., during loading operation), during transit on the road network **110**, e.g., when the charger **104** may be getting shipped from the source location **106** to the destination location **108** in the vehicle **102**, and/or at the destination location **108** (e.g., during the pre-installation phase when the customer may have received the charger **104**, but may not have yet installed the charger **104**). The charger **104** may also encounter adverse situations after the charger **104** gets installed at the destination location **108**. In some aspects, the adverse situation may result in the charger **104** getting dents or scratches, or one or more charger components may get broken when the charger **104** encounters an adverse situation.

[0021] The charger **104** may be configured to determine when an adverse situation may be encountered by the charger **104**, and store details associated with the adverse situation in a system memory (shown as memory **218** in FIG. **2**) and/or transmit the details to a server (shown as server **202** in FIG. **2**) and/or a user device (shown as user device **204** in FIG. **2**). Specifically, the charger **104** may be configured to determine whether the charger **104** encounters the adverse situation during transit (or in a charger's "transit state") when the charger **104** may be getting shipped from the source location **106** to the destination location **108** via the vehicle **102**, or in a charger's "pre-installation state" when the charger **104** may be delivered to the destination location **108** but not yet installed, or in a charger's "installed state" when the charger **104** may be installed at the destination location **108**. The customer, a charger original equipment manufacturer (OEM)/manufacturer, a transport firm associated with the vehicle **102**, an insurance firm, and/or the like, may access the server, the user device and/or the system memory to view the details associated with the adverse situation, and identify a potential reason for the adverse situation and/or a party responsible for the adverse situation (e.g., the customer, a vehicle operator associated with the vehicle **102**, a warehouse operator, a user charging a vehicle at the destination location **108** using the charger **104**, and/or the like). The process of determining the details associated with the adverse situation, and storing and/or transmitting the details, is described briefly below and in detail later in the description in conjunction with FIG. **2**.

[0022] In some aspects, the charger **104** may include a detection unit (shown as detection unit **212** in FIG. **2**) that may be configured to measure a level of nonconforming or unusual movement associated with the charger **104**. In an exemplary aspect, the detection unit may be an accelerometer that may be configured to measure an amount of abrupt longitudinal and/or lateral movement associated with the charger **104**, when the charger **104** may be in the transit state, the pre-installation state, or the installed state. The charger **104** may continuously or at a predefined frequency monitor the level of nonconforming movement measured by the detection unit, and may perform one or more predefined actions when the level of nonconforming movement exceeds a predefined threshold, based on the state of the charger **104**.

[0023] Specifically, the charger **104** may first determine the charger state (from the three states described above, i.e., the transit state, the pre-installation state, or the installed state) in which the charger **104** may be in. In some aspects, the charge state may be set by a charger operator, an operator associated with the vehicle **102**, a charger OEM/manufacturer, the customer, and/or the like. The charger **104** may also "auto-set" its own state based on a charger's geolocation, inputs received from one or more operators described above, and/or a supply of external power being fed to the charger **104** (e.g., when the charger **104** may be getting installed at the destination location **108**).

[0024] Responsive to determining the charger state, the charger **104** may identify an optimal/appropriate or "permissible" threshold of nonconforming movement (or an "optimal movement threshold") that may be deemed as normal or usual for the charger **104**, based on the charger state. As an example, the optimal movement threshold may have a higher value when the charger **104** may be in the transit state (and, e.g., when the road network **110** may be bumpy), and may have a lower value when the charger **104** may be in the installed state.

[0025] Responsive to identifying the optimal movement threshold, the charger **104** may compare the level of nonconforming movement measured by the detection unit with the identified optimal movement threshold, and perform a predefined action when the measured level of nonconforming movement exceeds the optimal movement threshold. In some aspects, the measured level of nonconforming movement exceeds the optimal movement threshold when, for example, the charger **104** encounters an adverse situation that may result in the charger **104** getting dents, scratches and/or the like, or result in one or more charger components getting broken. The predefined action performed by the charger **104** may be based on the charger state in which the charger **104** may be in.

[0026] As an example, when the charger **104** may be in the transit state and the measured level of nonconforming movement exceeds the optimal movement threshold for the transit state (e.g., a "first movement threshold"), the charger **104** may first cause a charger battery (shown as battery **210** in FIG. **2**) to provide power to a charger's telematics control unit ("TCU", shown as TCU **214** in FIG. **2**) and/or a geolocation unit (shown geolocation unit **208** in FIG. **2**). Stated another way, the charger **104** may cause the TCU and/or the geolocation unit to "wake-up" (by powering them using the charger's battery power), when the measured level of nonconforming movement exceeds the first movement threshold in the system's transit state. In some aspects, the geolocation unit may determine a real-time system location when the geolocation unit is powered, and the TCU may be configured to transmit signals/data to external systems when the TCU is powered.

[0027] Responsive to powering the TCU and/or the geolocation unit, the charger **104** may cause the TCU to transmit details associated with the "event" or the "adverse situation" that may have caused the measured level of nonconforming movement to exceed the optimal movement threshold to the server and/or the user device. In an exemplary aspect, the details may include a system geolocation when the adverse situation may have occurred (as determined by the geolocation unit), information associated with date and time when the adverse situation may have occurred, the level of nonconforming movement measured by the detection unit when the adverse situation may have occurred, and/or the like. In additional or alternative aspects, the charger **104** may store the details described above in the system memory.

[0028] An operator associated with the charger OEM/manufacturer, the transport firm associated with the vehicle **102**, and/or the like may access the server and/or the user device to view the details associated with the adverse situation to ascertain whether the charger **104** may have received dents, scratches, etc. due to the adverse situation and to determine a party responsible for the adverse situation. The customer receiving the charger **104** at the destination location **108** may also visually inspect the charger **104** to identify any potential dents, scratches, etc., and access the server and/or the user device to view a charger's "shipping log" or "transit log" and/or to determine a party responsible for the dents, scratches, etc. (if the customer identifies dents based on the visual inspection) based on the shipping log. The customer may also access/view the charger's shipping or transit log by accessing the system memory. In this manner, all the parties involved in charger manufacturing, loading/unloading, shipping, receiving, installing, etc., may transparently view the details associated with an adverse situation potentially encountered by the charger **104**, and may accordingly identify a party responsible for the adverse situation. This may make the process of charger repair (if required), obtaining funds for the charge repair, claiming insurance, etc., easier and convenient for all the involved parties.

[0029] In some aspects, the customer may refuse to receive the charger **104** at the destination location **108** when the charger **104** may have encountered an adverse situation in the transit state (resulting in dents, scratches and/or broken charge components), or may receive the charger **104** at the destination location **108** when the charger **104** may be in an acceptable condition (i.e., when the charger **104** may not have encountered any adverse situation in the transit state, and/or may not have any dents, scratches and/or broken charger components).

[0030] In some aspects, when the charger **104** may be received at the destination location **108** by the customer, the customer and/or a vehicle operator may change the charger state from the transit state to the pre-installation state (or the charger **104** may itself change its state to the pre-installation state). Responsive to the charger state being changed to the pre-installation state, the charger **104** may identify the optimal movement threshold (e.g., a "second movement threshold") associated with the charger **104** in the pre-installation state. In some aspects, the second movement threshold may be different from the first movement threshold. In the pre-installation state as well, the charger **104** may monitor the level of nonconforming movement measured by the detection unit, and perform one or more predefined actions when the measured level of nonconforming movement exceeds the second movement threshold. For example, the charger **104** may power or "wake-up" the TCU and/or the geolocation unit, and transmit the details associated with the adverse situation (i.e., when the measured level of nonconforming movement exceeded the second movement threshold) to the server and/or the user device. The charger **104** may further store the details in the system memory. In this case as well, the operator associated with the charger OEM/manufacturer, the transport firm associated with the vehicle **102**, and/or the like may access the server and/or the user device to view the details associated with the adverse situation, and determine whether the charger **104** may have encountered the adverse situation in the pre-installation state due to mishandling by the customer (and may accordingly plan future actions).

[0031] In further aspects, when the charger **104** may be powered at the destination location **108** and get installed, the customer and/or a charger operator may change the charger state to the installed state (or the charger **104** may itself change its state to the installed state). Responsive to the charger state being changed to the installed state, the charger **104** may identify the optimal movement threshold (e.g., a "third movement threshold") associated with the charger **104** in the installed state. In some aspects, the third movement threshold may be different from the first and second movement thresholds described above. Further, the third movement threshold may be adaptable or modifiable. Stated another way, the charger **104** may modify the third movement threshold based on a plurality of parameters such as ambient temperature and/or humidity level, a type of operation being performed using the charger **104**, loads connected to the charger **104**, and/or the like. In a similar manner, in some aspects, the first and second movement threshold may also be adaptable or modifiable, based on a plurality of parameters.

[0032] In the installed state as well, the charger **104** may monitor the level of nonconforming movement measured by the detection unit, and perform one or more predefined actions when the measured level of nonconforming movement exceeds the third movement threshold. Examples of the predefined actions performed by the charger **104** in the installed state, and further charger details are described in detail below in conjunction with FIG. **2**.

[0033] The vehicle **102** and the charger **104** implement and/or perform operations, as described here in the present disclosure, in accordance with the owner manual and safety guidelines. In addition, any action taken by the operator/customer associated with the charger **104** based on the notifications provided by the charger **104** should comply with all the rules specific to the location and operation of the charger **104** (e.g., Federal, state, country, city, etc.). The notifications, as provided by the charger **104** should be treated as suggestions and only followed according to any rules specific to the location and operation of the charger **104**.

[0034] FIG. **2** depicts a block diagram of the electric vehicle charger **104** (or charger **104**) in accordance with the present disclosure. While describing FIG. **2**, references will be made to FIGS. **3** and **4**.

[0035] The charger **104** may be communicatively coupled with one or more servers **202** (or server **202**) and a user device **204** via one or more networks **206** (or network **206**). In some aspects, the server **202** may be associated with a charger OEM/manufacturer. In other aspects, the server **202** may be associated with a transport firm operating the vehicle **102**. In yet another aspect, the server **202** may be associated with an insurance firm or a firm configured to repair the charger **104** and/or fund the charger's repair.

[0036] In some aspects, the user device **204** may be associated with the customer who may receive the charger **104** at the destination location **108**. In other aspects, the user device **204** may be associated with an operator associated with the charger OEM/manufacturer, the vehicle **102**, the transport firm operating the vehicle **102**, the insurance firm, and/or the like. The user device **204** may be, for example, a mobile phone, a laptop, a computer, a tablet, a wearable device, or any other device with communication capabilities.

[0037] The network **206** illustrates an example communication infrastructure in which the connected devices discussed in various embodiments of this disclosure may communicate. The network **206** may be and/or include the Internet, a private network, public network or other configuration that operates using any one or more known communication protocols such as, for example, transmission control protocol/Internet protocol (TCP/IP), Bluetooth®, Bluetooth® Low Energy (BLE), Wi-Fi based on the Institute of Electrical and Electronics Engineers (IEEE) standard 802.11, ultra-wideband (UWB), and cellular technologies such as Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), High-Speed Packet Access (HSPDA), Long-Term Evolution (LTE), Global System for Mobile Communications (GSM), and Fifth Generation (5G), to name a few examples.

[0038] The charger **104** may include a plurality of units including, but not limited to, a geolocation unit **208**, a battery **210**, a detection unit **212**, a telematics control unit (TCU) **214**, a processor **216** and a memory **218**, communicatively coupled with each other. The geolocation unit **208** may be configured to determine/detect a real-time system geolocation or real-time charger geolocation, and the TCU **214** may be configured to transmit signals or data to one or more external devices or systems, e.g., the server **202**, the user device **204**, and/or the like. In some aspects, the geolocation unit **208** may be part of the TCU **214**. In other aspects, the geolocation unit **208** may be separate from the TCU **214**, as shown in FIG. **2**.

[0039] The battery **210** may be configured to store and provide power/energy to the geolocation unit **208**, the TCU **214** and/or other charger components when the charger **104** may not be connected with a utility power supply. In some aspects, the detection unit **212** may include an accelerometer, and may be configured to measure the level of nonconforming movement associated with the charger **104**, when the charger **104** may be in any one of a plurality of charger installation states, i.e., the transit state, the preinstallation state or the installed state. Stated another way, the detection unit **212** may measure a level of abrupt charger movement (e.g., abrupt longitudinal or lateral charger movement) when the charger **104** may be in any one of the plurality of charger installation states.

[0040] The processor **216** may be disposed in communication with one or more memory devices disposed in communication with the respective computing systems (e.g., the memory **218** and/or one or more external databases not shown in FIG. **2**). The processor **216** may utilize the memory **218** to store programs in code and/or to store data for performing aspects in accordance with the disclosure. The memory **218** may be a non-transitory computer-readable storage medium or memory storing a program code that enables the processor **216** to perform operations in accordance with the present disclosure. The memory **218** may include any one or a combination of volatile memory elements (e.g., dynamic random-access memory (DRAM), synchronous dynamic random-access memory (SDRAM), etc.) and may include any one or more nonvolatile memory elements (e.g., erasable programmable read-only memory (EPROM), flash memory, electronically erasable programmable read-only memory (EEPROM), programmable read-only memory (PROM), etc.).

[0041] The memory **218** may be configured to store charger details or charger information. In some aspects, the memory **218** may include an adverse situation information database **220** that may be configured to store details associated with the adverse situation(s) encountered by the charger **104** in the transit state, the pre-installation state, or the installed state. The details associated with the adverse situation are briefly described above in conjunction with FIG. **1**, and described in detail later in the description below.

[0042] In operation, when the charger **104** may be loaded into the vehicle **102** and may be ready to be shipped from the source location **106** to the destination location **108**, an operator associated with the vehicle **102** or the charger OEM/manufacturer may fully charge the battery **210**, and set the charger state to the transit state. In additional or alternative aspects, the charger **104** may itself set its state to the transit state when the charger **104** may be getting shipped from the source location **106** to the destination location **108**. When the charger state may be set to the transit state, the processor **216** may determine the charger state (i.e., the transit state), from the plurality of charger states (i.e., the transit state, the pre-installation state, and the installed state), and may accordingly identify an optimal movement threshold (from a plurality of movement thresholds associated with the plurality of charger states) for the charger **104** associated with the transit state. For example, in this case, since the charger **104** may be in the transit state, the processor **216** may identify the first movement threshold as the optimal movement threshold for the charger **104** (as described above in conjunction with FIG. **1**), from the first, second and third movement thresholds.

[0043] Further, as the charger **104** may be getting shipped from the source location **106** to the destination location **108** via the vehicle **102** in the transit state, the processor **216** may continuously (or at a predefined frequency) obtain the level of nonconforming movement associated with the charger **104** from the detection unit **212**. The processor **216** may further compare the level of nonconforming movement with the first movement threshold, and may perform one or more predefined actions when the processor **216** determines that the measured level of nonconforming movement may be greater than the first movement threshold. Stated another way, the processor **216** may perform one or more predefined actions when a level of abrupt charger movement may be greater than the first movement threshold. In some aspects, the level of nonconforming movement may be greater than the first movement threshold when, for example, the charger **104** may have encountered an adverse situation during the transit from the source location **106** to the destination location **108**, which may potentially result in dents, scratches and/or charger component breakage.

[0044] Examples of the predefined actions performed by the processor **216** responsive to determining that the measured level of nonconforming movement may be greater than the first movement threshold are described below. The examples described below should not be construed as limiting, and the processor **216** may perform additional actions as well, without departing from the present disclosure scope.

[0045] In an exemplary aspect, responsive to determining that the measured level of nonconforming movement may be greater than the first movement threshold, the processor **216** may cause the battery **210** to provide power/energy to (or to "wake-up") the TCU **214** and the geolocation unit **208**. When the geolocation unit **208** may be powered-up, the geolocation unit **208** may determine a real-time charger geolocation (or a "charger geolocation") when the level of nonconforming movement may have exceeded the first movement threshold. Stated another way, when the geolocation unit **208** may be powered-up, the geolocation unit **208** may determine the charger geolocation where the charger **104** may have encountered the adverse situation.

[0046] Further, when the TCU **214** may be powered-up, the processor **216** may cause the TCU **214** to transmit a first alert notification (or information/details associated with the adverse situation) to the server **202** and/or the user device **204**, via the network **206**. In some aspects, the first alert notification may include the charger geolocation when the level of nonconforming movement may have exceeded the first movement threshold or when the charger **104** may have encountered the adverse situation, information associated with date and time when the level of nonconforming movement may have exceeded the first movement threshold, and/or information associated with the level of nonconforming movement measured by the detection unit **212** when the charger **104** may have encountered the adverse situation.

[0047] The operator associated with the server **202** and/or the user device **204** may view the first alert notification (and other similar alert notifications that may be transmitted by the TCU **214** when the charger **104** may be in the transit state), and may understand the potential reasons, location, and/or the responsible party for the charger adverse situation based on the first alert notification. An example view of a "shipping event log" or a log of a plurality of alert notifications (similar to the first alert notification described above) being displayed on the user device **204** is shown in FIG. **3**. A person ordinarily skilled in the art may appreciate that such a shipping event log may enable the operator associated with the user device **204** to conveniently determine if a potential dent or scratch on the charger **104** and/or a broken charger component may have been caused by a user/driver operating the vehicle **102** and/or a transport firm personnel responsible for shipping the charger **104** from the source location **106** to the destination location **108**.

[0048] In some aspects, when the battery **210** may not have enough power/energy to power-up or energize the TCU **214** when the charger **104** encounters an adverse situation in the transit state (i.e., when the level of nonconforming movement exceeds the first movement threshold), the processor **216** may cause the battery **210** to provide power only to the geolocation unit **208**. In this case, instead of transmitting the details associated with the adverse situation to the server **202** and/or the user device **204** as described above, the processor **216** may store the details in the memory **218** (specifically the adverse situation information database **220**). Stated another way, in this case, the processor **216** may store the charger geolocation when the level of nonconforming movement may have exceeded the first movement threshold or when the charger **104** may have encountered the adverse situation, information associated with date and time when the level of nonconforming movement may have exceeded the first movement threshold, and/or information associated with the level of nonconforming movement measured by the detection unit **212** when the charger **104** may have encountered the adverse situation, in the memory **218**.

[0049] In additional or alternative aspects, the processor **216** may store the details associated with the adverse situation described above in the memory **218**/adverse situation information database **220** even when the battery **210** may have enough power/energy to energize the TCU **214**. In this case, the TCU **214** may transmit the details to the server **202** and/or the user device **204**, and the processor **216** may, in parallel, store the details in the memory **218**.

[0050] When the vehicle **102** reaches the destination location **108**, the charger **104** may be unloaded from the vehicle

102. At this point, the customer at the destination location **108** may transmit, via a customer device (not shown), a shipping log request to the server **202**. Responsive to receiving the shipping log request from the customer device, the server **202** may transmit a wake-up signal (e.g., a low-power radio message/signal) to the charger **104** to "wake-up" or "power-up".

[0051] The processor **216** may obtain the wake-up signal from the server **202**, and may cause the battery **210** to provide power/energy to the TCU **214** and/or a charger user interface (shown as charger user interface **402** in FIG. **4**) responsive to obtaining the wake-up signal. The processor **216** may further cause the TCU **214** to transmit the details associated with the adverse situation(s) encountered by the charger **104** during the transit state (that may be stored in the memory **218**) to the server **202** and/or the user device **204**, responsive to energizing the TCU **214**. In additional or alternative aspects, the processor **216** may cause the charger user interface **402** to display the details associated with the adverse situation(s) encountered by the charger **104** during the transit state (that may be stored in the memory **218**), responsive to energizing the charger user interface **402**, as shown in a view **404** of FIG. **4**.

[0052] The customer at the destination location **108** may view the details described above by accessing the server **202**, and/or by viewing the details on the charger user interface **402**. The customer may also visually inspect the charger **104**. If the customer identifies any dents, scratches, etc., on the charger **104** due to the adverse situations potentially encountered by the charger **104** in the transit state, the customer may decide not to accept or receive the charger **104**. In this case, the details associated with the adverse situations stored in the server **202** and/or the memory **218** may facilitate in determining a party (e.g., the operator associated with the vehicle **102** or the shipping firm) responsible for the charger dent, scratches, etc., and may accordingly fund the charger repair (or assist in insurance claim).

[0053] On the other hand, when the charger **104** may be in an acceptable condition, the customer at the destination location **108** may accept/receive the charger **104**. At this point, the customer or an operator associated with the charger **104**/vehicle **102** may set the charger state to the pre-installation state. In alternative aspects, at this point, the charger **104** may itself set its state to the pre-installation state.

[0054] When the charger state changes to the pre-installation state, the processor **216** may determine an optimal movement threshold (e.g., the second movement threshold) associated with the pre-installation state. In some aspects, the second movement threshold may be different from the first movement threshold. In other aspects, the second movement threshold may be same as the first movement threshold.

[0055] In the pre-installation state also, similar to the transit state, the processor **216** may continuously (or at a predefined frequency) obtain the level of nonconforming movement associated with the charger **104** from the detection unit **212**. The processor **216** may further compare the level of nonconforming movement with the second movement threshold, and may perform one or more predefined actions when the processor **216** determines that the measured level of nonconforming movement may be greater than the second movement threshold. For example, in this case, responsive to determining that the level of nonconforming movement may be greater than the second movement threshold, the processor **216** may cause the battery **210** to provide power to the TCU **214** and the geolocation unit **208**, and cause the TCU **214** to transmit a second alert notification to the server **202** and/or the user device **204** when the TCU **214** wakes up or gets powered. The second alert notification (or details/information associated with the adverse situation when the charger state may be the pre-installation state) may be similar to the first alert notification, and may include, for example, the charger geolocation when the level of nonconforming movement may have exceeded the second movement threshold or when the charger **104** may have encountered the adverse situation, information associated with date and time when the level of nonconforming movement may have exceeded the second movement threshold, and/or information associated with the level of nonconforming movement measured by the detection unit **212** when the charger **104** may have encountered the adverse situation.

[0056] The second alert notification may facilitate an operator associated with the server **202** and/or the user device **204** to determine whether the customer at the destination location **108** may have mishandled the charger **104** and caused dents, scratches, etc. to the charger **104**.

[0057] When no adverse situation may be encountered by the charger **104** during the pre-installation state, the customer or the charger operator may plug the charger **104** to a utility power source, thereby installing the charger **104** at the destination location **108**. At this point, the customer or the charger operator may change the charger state to the installed state, or the charger **104** may itself change its state to the installed state when the charger **104** may be plugged in. In some aspects, the charger components/units may get energized or draw power from the utility power source, when the charger **104** may be in the installed state.

[0058] When the charger state may be changed to the installed state, the processor **216** may cause the TCU **214** to transmit the information stored in the memory **218**/adverse situation information database **220** to the server **202** and/or the user device **204** for record-keeping purpose. Stated another way, when the charger state may be changed to the installed state, the processor **216** may cause the TCU **214** to transmit the details associated with the adverse situation (if any) encountered by the charger **104** during the transit state and the pre-installation state to the server **202** and/or the user device **204** for record-keeping purpose.

[0059] Further, when the charger state may be the installed state, the processor **216** may cause the TCU **214** to transmit the real-time charger geolocation detected by the geolocation unit **208**, time and date information/timestamp, and information associated with the level of nonconforming movements measured by the detection unit **212** to the server **202** and/or the user device **204** at a predefined frequency or a regular cadence, for record-keeping purpose.

[0060] In further aspects, when the charger state may be the installed state, the processor **216** may continuously (or at a predefined frequency) monitor a power supply from the utility power source to the charger **104**. In an exemplary aspect, the processor **216** may perform one or more predefined actions when the processor **216** determines that the power supply to the charger **104** may be interrupted in the installed state. As an example, when the power supply to the charger **104** may be interrupted, the processor **216** may cause the battery **210** to provide power to the TCU **214**. Responsive to powering-up the TCU **214**, the processor **216** may cause the TCU **214** to transmit a power outage notification to the server **202** and/or the user device **204**, so that the operator/customer associated with the server **202**/user device **204** may know that the power supply to the charger **104** may have been interrupted.

[0061] As another example, when the power supply to the charger **104** may be interrupted, the processor **216** may cause the battery **210** to provide power to the TCU **214** and the geolocation unit **208**. The processor **216** may further determine an optimal movement threshold (e.g., the third movement threshold) associated with the installed state, and determine if the level of nonconforming movement measured by the detection unit **212** exceeds the third movement threshold. In some aspects, the level of nonconforming movement may exceed the third movement threshold when the charger **104** encounters an adverse situation in the installed state. In an exemplary aspect, the third movement threshold may be different from the first and second movement thresholds described above.

[0062] Responsive to determining that the level of nonconforming movement may have exceeded the third movement threshold, the processor **216** may cause the TCU **214** to transmit the charger geolocation when the level of nonconforming movement may have exceeded the third movement threshold, time and date information when the level of nonconforming movement may have exceeded the third movement threshold, information associated with the level of nonconforming movement, and/or the like, to the server **202** and/or the user device **204**. In additional aspects, in this case, the processor **216** may cause the TCU **214** to transmit information associated with a type of vehicle/load (e.g., the vehicle **114**) that may have been connected to the charger **104** before or after the event (i.e., the adverse situation) that may have caused the level of nonconforming movement to exceed the third movement threshold. Such an information may assist an operator associated with the server **202** and/or the user device **204** to determine a party that may be responsible for the adverse situation associated with the charger **104** in the installed state.

[0063] In some aspects, the step of comparing the level of nonconforming movement with the third movement threshold, and performing the predefined action when the nonconforming movement exceeds the third movement threshold (as described above) may also be performed by the processor **216** when the power supply to the charger **104** may not be interrupted. Stated another way, in some aspects, the processor **216** may execute the steps of comparing and performing the predefined action irrespective of whether the power supply to the charger **104** is interrupted or not interrupted.

[0064] In some aspects, the first, second and third movement thresholds described above may be adjustable or modifiable by the processor **216** based on a plurality of parameters. For example, the processor **216** may adjust the first movement threshold based on a charger type, a type of packaging disposed on the charger **104** before the charger **104** may be loaded onto the vehicle **102**, type of roads (e.g., smooth, bumpy, etc.) on the road network **110**, a level of energy stored in the battery **210**, and/or the like. Similarly, the processor **216** may adjust the second and third movement thresholds based on an ambient temperature level, an ambient humidity level, the destination location **108** or the charger geolocation, the battery energy level, and/or the like. As an example, the second and/or the third movement threshold may have a higher value when the ambient humidity level may be high. In some aspects, the processor **216** may determine the ambient humidity level via the charger user interface **402**. In other aspects, the processor **216** may determine the ambient humidity level and/or the temperature level based on inputs obtained from the server **202**.

[0065] In further aspects, the processor **216** may adjust the third movement threshold based on a step in an electric vehicle (EV) charging process being performed using the charger **104**, charger loads or loads being attached to the charger **104**, a level of charger wear and tear over time (e.g., wear and tear due to the charger connector getting plugged/unplugged multiple times with frequent use), user inputs, time and date information, and/or the like. A person ordinarily skilled in the art may appreciate that there are known shock levels or nonconforming movements for steps/items associated with an EV charging process, such as plugging/unplugging a charging cord/connector, interacting with the charger user interface **402**, and/or the like. The processor **216** uses such known shock levels to calibrate or adjust the third movement threshold, when the charger **104** may be in the installed state. As an example, cutting a charging cable off may require a certain level of force that may not be consistent with normal operational measurements/known shock levels. In this case, the processor **216** may identify such instances as “adverse situations” associated with the charger **104**, and may perform one or more predefined actions described above responsive to identifying such instances. Parties/users responsible for such instances (e.g., theft, vandalism, improper use, etc.) may be alerted and/or not allowed to use the charger **104** in the future. Similarly, depending on the step in the EV charging process (removing cord, plugging back in, etc.) being performed on the charger **104**, the processor **216** may accordingly compare the level of shock/nonconforming movements with the third movement threshold, to report any potential adverse situation associated with the charger **104**. In some aspects, the customer may also calibrate the detection unit **212**/accelerometer via recorded normal operation repetitive events, and verify that accelerometer operations are working fine over time.

[0066] A person ordinarily skilled in the art may appreciate from the description above that the charger **104** facilitates in determining a potential reason for the charger fault or dent, during different states of charger installation/operation, e.g., the transit state, the pre-installation state, the installed state, a repair state, and/or the like. Further, different levels or types of adverse situations have different signatures of nonconforming charger movements or shock levels measured by the detection unit **212**/accelerometer. An operator associated with the server **202** and/or the user device **204** may determine a potential type of adverse situation encountered by the charger **104** by reviewing the corresponding (signature of) nonconforming charger movement or shock level measured by the detection unit **212**/accelerometer. This may further assist the operator to identify a potential reason for the adverse situation, and plan remedial actions to prevent similar adverse situations in the future.

[0067] FIG. **5** depicts a flow diagram of an example method **500** for monitoring the electric vehicle charger **104** in accordance with the present disclosure. FIG. **5** may be described with continued reference to prior figures. The following process is exemplary and not confined to the steps described hereafter. Moreover, alternative embodiments may include more or less steps than are shown or described herein and may include these steps in a different order than the order described in the following example embodiments.

[0068] The method **500** starts at step **502**. At step **504**, the method **500** may include determining, by the processor **216**, the charger state (or a system installation state) in which the charger **104** may be in (from the transit state, the pre-installation state, and the installed state). At step **506**, the method **500** may include identifying, by the processor **216**, an optimal movement threshold, from the first, second and third movement thresholds, based on the determined charger state.

[0069] At step **508**, the method **500** may include determining, by the processor **216**, that the level of nonconforming movement associated with the charger **104** measured by the detection unit **212** may be greater than the identified optimal movement threshold. At step **510**, the method **500** may include performing, by the processor **216**, a predefined action responsive to determining that the level of nonconforming movement may be greater than the optimal movement threshold. The examples of the predefined action(s) performed by the processor **216** are described above in conjunction with FIG. **2**.

[0070] At step **512**, the method **500** may stop.

[0071] In the above disclosure, reference has been made to the accompanying drawings, which form a part hereof, which illustrate specific implementations in which the present disclosure may be practiced. It is understood that other implementations may be utilized, and structural changes may be made without departing from the scope of the present disclosure. References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a feature, structure, or characteristic is described in connection with an embodiment, one skilled in the art will recognize such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0072] Further, where appropriate, the functions described herein can be performed in one or more of hardware, software, firmware, digital components, or analog components. For example, one or more application specific integrated circuits (ASICs) can be programmed to carry out one or more of the systems and procedures described herein. Certain terms are used throughout the description and claims refer to particular system components. As one skilled in the art will appreciate, components may be referred to by different names. This document does not intend to distinguish between components that differ in name, but not function.

[0073] It should also be understood that the word "example" as used herein is intended to be non-exclusionary and non-limiting in nature. More particularly, the word "example" as used herein indicates one among several examples, and it should be understood that no undue emphasis or preference is being directed to the particular example being described.

[0074] A computer-readable medium (also referred to as a processor-readable medium) includes any non-transitory (e.g., tangible) medium that participates in providing data (e.g., instructions) that may be read by a computer (e.g., by a processor of a computer). Such a medium may take many forms, including, but not limited to, non-volatile media and volatile media. Computing devices may include computer-executable instructions, where the instructions may be executable by one or more computing devices such as those listed above and stored on a computer-readable medium.

[0075] With regard to the processes, systems, methods, heuristics, etc. described herein, it should be understood that, although the steps of such processes, etc. have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words, the descriptions of processes herein are provided for the purpose of illustrating various embodiments and should in no way be construed so as to limit the claims.

[0076] Accordingly, it is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments and applications other than the examples provided would be apparent upon reading the above description. The scope should be determined, not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. It is anticipated and intended that future developments will occur in the technologies discussed herein, and that the disclosed systems and methods will be incorporated into such future embodiments. In sum, it should be understood that the application is capable of modification and variation.

[0077] All terms used in the claims are intended to be given their ordinary meanings as understood by those knowledgeable in the technologies described herein unless an explicit indication to the contrary is made herein. In particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary. Conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments could include, while other embodiments may not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more embodiments.

That which is claimed is:

1. A system comprising:

a detection unit configured to measure a level of nonconforming movement associated with the system; and

a processor communicatively coupled with the detection unit, wherein the processor is configured to:

determine a system installation state from a plurality of system installation states;

identify an optimal movement threshold, from a plurality of movement thresholds associated with the plurality of system installation states, based on the system installation state;

determine that the level of nonconforming movement is greater than the optimal movement threshold; and

perform a predefined action responsive to determining that the level of nonconforming movement is greater than the optimal movement threshold.

2. The system of claim **1**, wherein the system is an electric vehicle charger.

3. The system of claim **1**, wherein the detection unit is an accelerometer.

4. The system of claim **1** further comprising:

a geolocation unit configured to detect a real-time system geolocation;

a telematics control unit configured to transmit signals or data to one or more external devices;

a memory configured to store system information; and

a battery configured to store and provide power to the telematics control unit and the geolocation unit.

5. The system of claim **4**, wherein the plurality of system installation states comprises a transit state, a pre-installation state, and an installed state.

6. The system of claim **5**, wherein the optimal movement threshold is a first movement threshold when the system installation state is the transit state, and wherein the predefined action comprises:

causing the battery to provide power to the telematics control unit and the geolocation unit when the level of nonconforming movement is greater than the first movement threshold; and

causing the telematics control unit to transmit a first alert notification to a server or a user device, wherein the first alert notification comprises one or more of a system geolocation when the level of nonconforming movement exceeded the first movement threshold, time and date information when the level of nonconforming movement exceeded the first movement threshold, and information associated with the level of nonconforming movement.

7. The system of claim **5**, wherein the optimal movement threshold is a first movement threshold when the system installation state is the transit state, and wherein the predefined action comprises:

causing the battery to provide power to the geolocation unit when the level of nonconforming movement is greater than the first movement threshold; and

storing one or more of a system geolocation when the level of nonconforming movement exceeded the first movement threshold, time and date information when the level of nonconforming movement exceeded the first movement threshold, and information associated with the level of nonconforming movement, in the memory.

8. The system of claim **7**, wherein the processor is further configured to:

obtain a wake-up signal from a server;

cause the battery to provide power to at least one of the telematics control unit or a system user interface, responsive to obtaining the wake-up signal; and

cause the telematics control unit to transmit information stored in the memory to a user device or the system user interface to display the information stored in the memory, wherein the information stored in the memory comprises one or more of the system geolocation, the time and date information, and the information associated with the level of nonconforming movement.

9. The system of claim **8**, wherein the processor is further configured to cause the telematics control unit to transmit the information stored in the memory to the server, when the system installation state changes to the installed state.

10. The system of claim **5**, wherein the optimal movement threshold is a second movement threshold when the system installation state is the pre-installation state, and wherein the predefined action comprises:

causing the battery to provide power to the telematics control unit and the geolocation unit, when the level of nonconforming movement is greater than the second movement threshold; and

causing the telematics control unit to transmit a second alert notification to a server or a user device, wherein the second alert notification comprises one or more of a system geolocation when the level of nonconforming movement exceeded the second movement threshold, time and date information when the level of nonconforming movement exceeded the second movement threshold, and information associated with the level of nonconforming movement.

11. The system of claim **5**, wherein the optimal movement threshold is a third movement threshold when the system installation state is the installed state.

12. The system of claim **11**, wherein the processor is further configured to cause the telematics control unit to transmit one or more of the real-time system geolocation detected by the geolocation unit, time and date information, and information associated with the level of nonconforming movement measured by the detection unit to a server at a predefined frequency, when the system installation state is the installed state.

13. The system of claim **11**, wherein the processor is further configured to:

determine that a power supply to the system is interrupted when the system installation state is the installed state; and

perform the predefined action responsive to determining that the power supply to the system is interrupted.

14. The system of claim **13**, wherein the predefined action comprises:

causing the battery to provide power to the telematics control unit and the geolocation unit; and

causing the telematics control unit to transmit one or more of a system geolocation when the level of nonconforming movement exceeded the third movement threshold, time and date information when the level of nonconforming movement exceeded the third movement threshold, information associated with the level of nonconforming movement, and a type of vehicle being connected to the system before or after an event when the level of nonconforming movement exceeded the third movement threshold.

15. The system of claim **13**, wherein the processor is further configured to:

cause the battery to provide power to the telematics control unit responsive to determining that the power supply to the system is interrupted; and

cause the telematics control unit to transmit a power outage notification to a server.

16. The system of claim **11**, wherein the processor is further configured to modify the third movement threshold based on at least one of: a step in an electric vehicle charging process being performed using the system, system loads, an ambient temperature level, an ambient humidity level, a level of system wear and tear over time, user inputs, a system geolocation, and time and date information.

17. A method comprising:

determining, by a processor, a system installation state from a plurality of system installation states associated with a system;

identifying, by the processor, an optimal movement threshold, from a plurality of movement thresholds associated with the plurality of system installation states, based on the system installation state;

determining, by the processor, that a level of nonconforming movement associated with the system measured by a detection unit is greater than the optimal movement threshold; and

performing, by the processor, a predefined action responsive to determining that the level of nonconforming movement is greater than the optimal movement threshold.

18. The method of claim **17**, wherein the system is an electric vehicle charger.

19. The method of claim **17**, wherein the detection unit is an accelerometer.

20. A non-transitory computer-readable storage medium having instructions stored thereupon which, when executed by a processor, cause the processor to:

determine a system installation state from a plurality of system installation states associated with a system;

identify an optimal movement threshold, from a plurality of movement thresholds associated with the plurality of system installation states, based on the system installation state;

determine that a level of nonconforming movement associated with the system measured by a detection unit is greater than the optimal movement threshold; and

perform a predefined action responsive to determining that the level of nonconforming movement is greater than the optimal movement threshold.

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