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(54) **MOBILE ROAD SURFACE TREATMENT SYSTEM**

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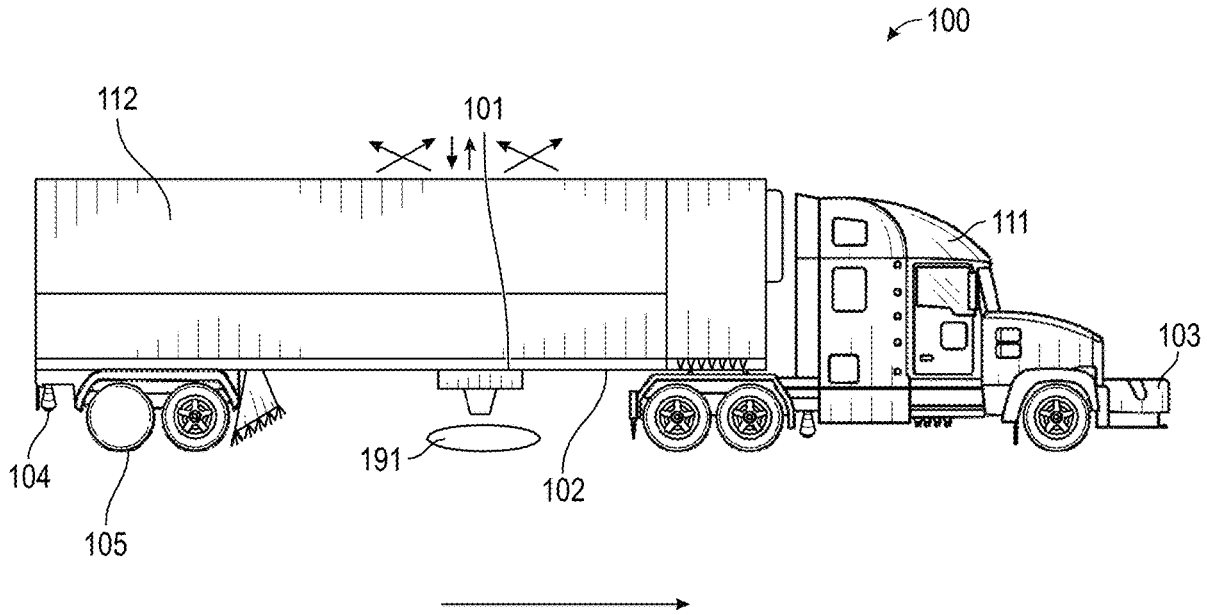
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(57) **ABSTRACT**

This is a mobile road surface treatment system, comprising a control module, a scanning module configured to detect a road cavity, and a material extrusion device mounted on a gantry on a vehicle configured to travel at a moving speed and moving direction. The system may be configured such that the control module instructs the material extrusion device to move on the gantry to hover above the road cavity and deposit repair material into the road cavity, corresponding to the moving speed and moving direction.



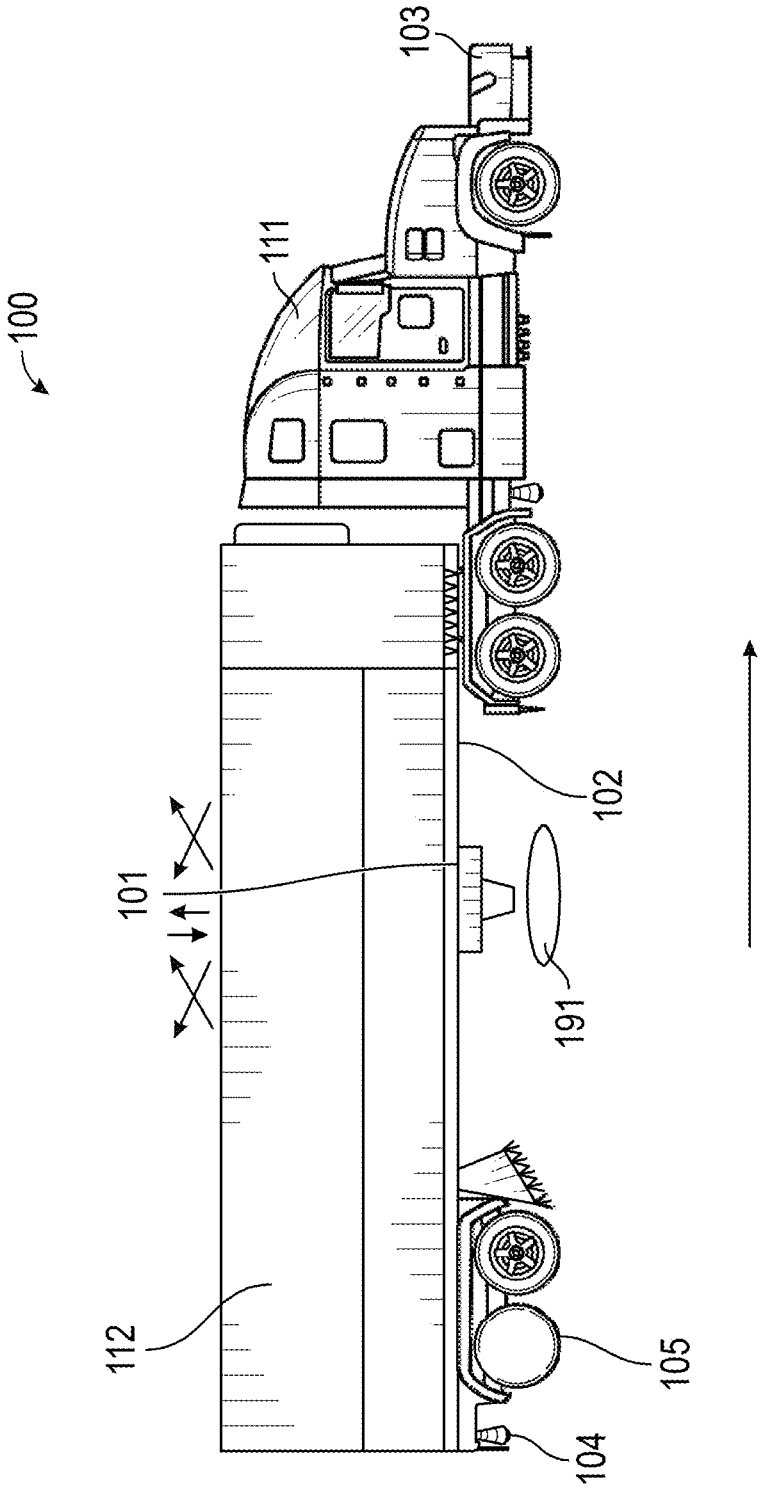


FIG. 1

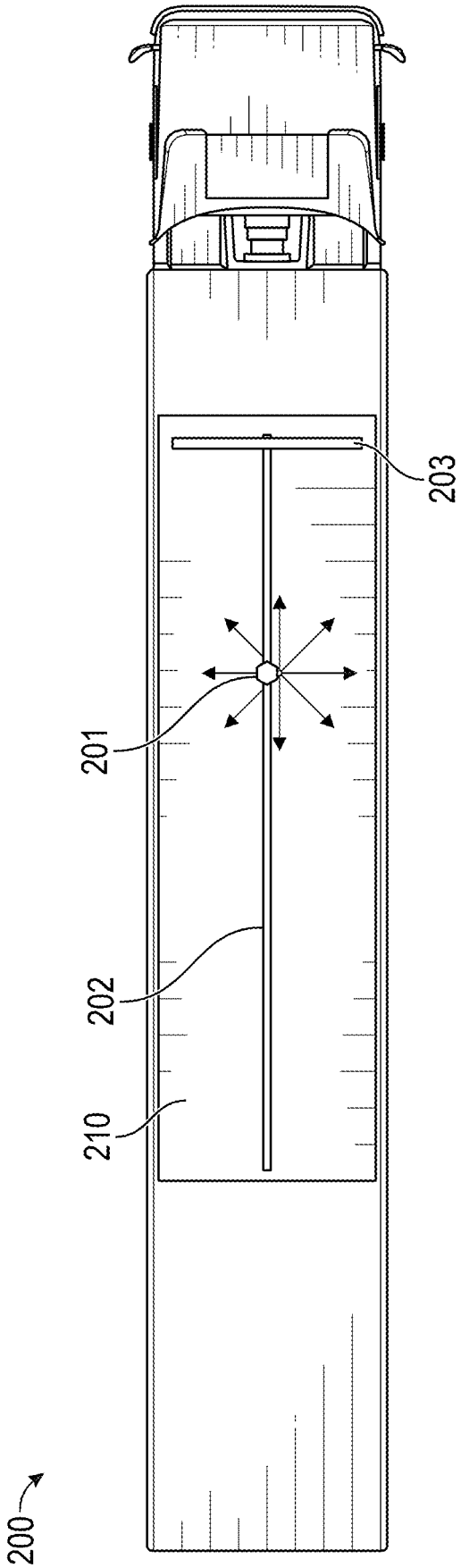


FIG. 2

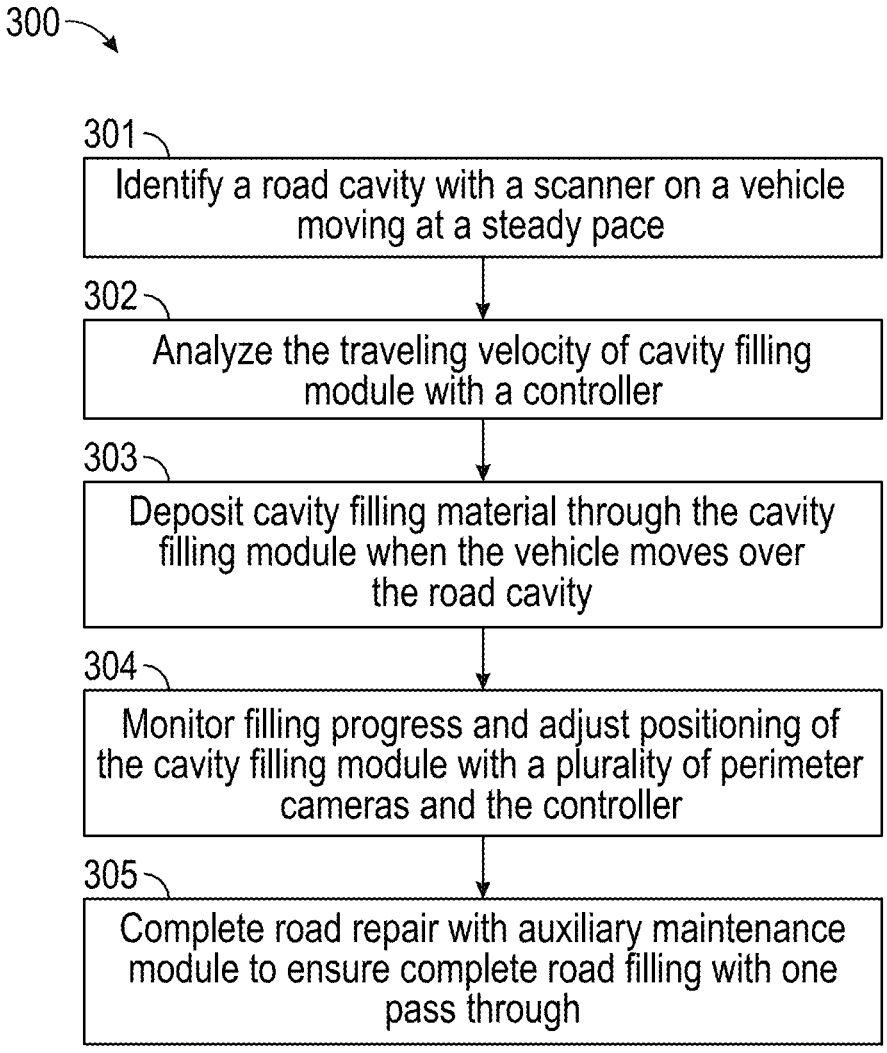

300
301
Identify a road cavity with a scanner on a vehicle moving at a steady pace
302
Analyze the traveling velocity of cavity filling module with a controller
303
Deposit cavity filling material through the cavity filling module when the vehicle moves over the road cavity
304
Monitor filling progress and adjust positioning of the cavity filling module with a plurality of perimeter cameras and the controller
305
Complete road repair with auxiliary maintenance module to ensure complete road filling with one pass through

FIG. 3

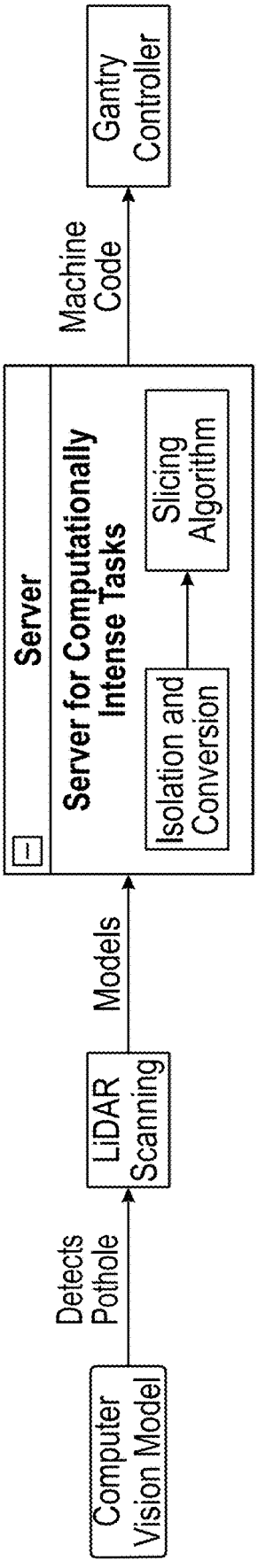

Computer Vision Model
Detects Pothole
LiDAR Scanning
Models
Server
Server for Computationally Intense Tasks
Isolation and Conversion
Slicing Algorithm
Machine Code
Gantry Controller

FIG. 4

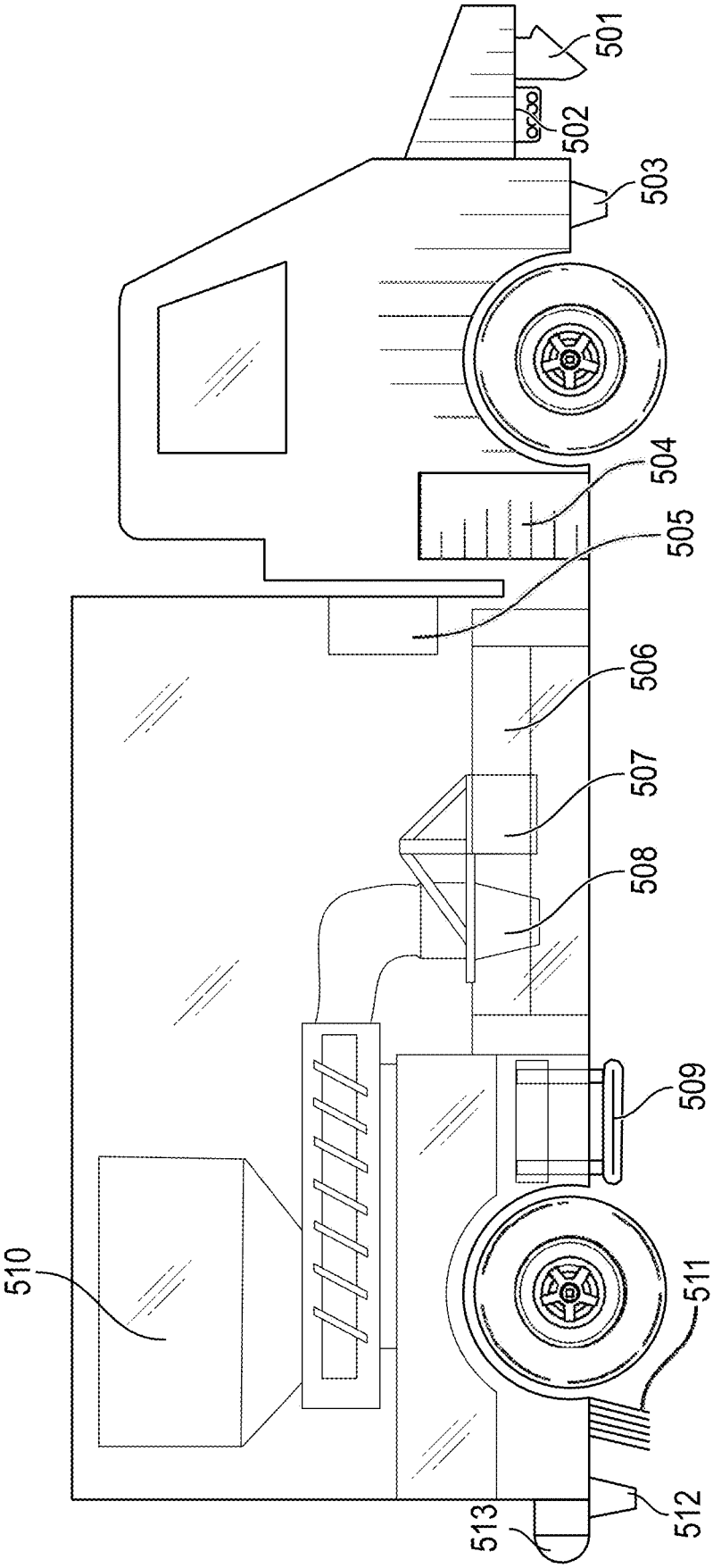


FIG. 5

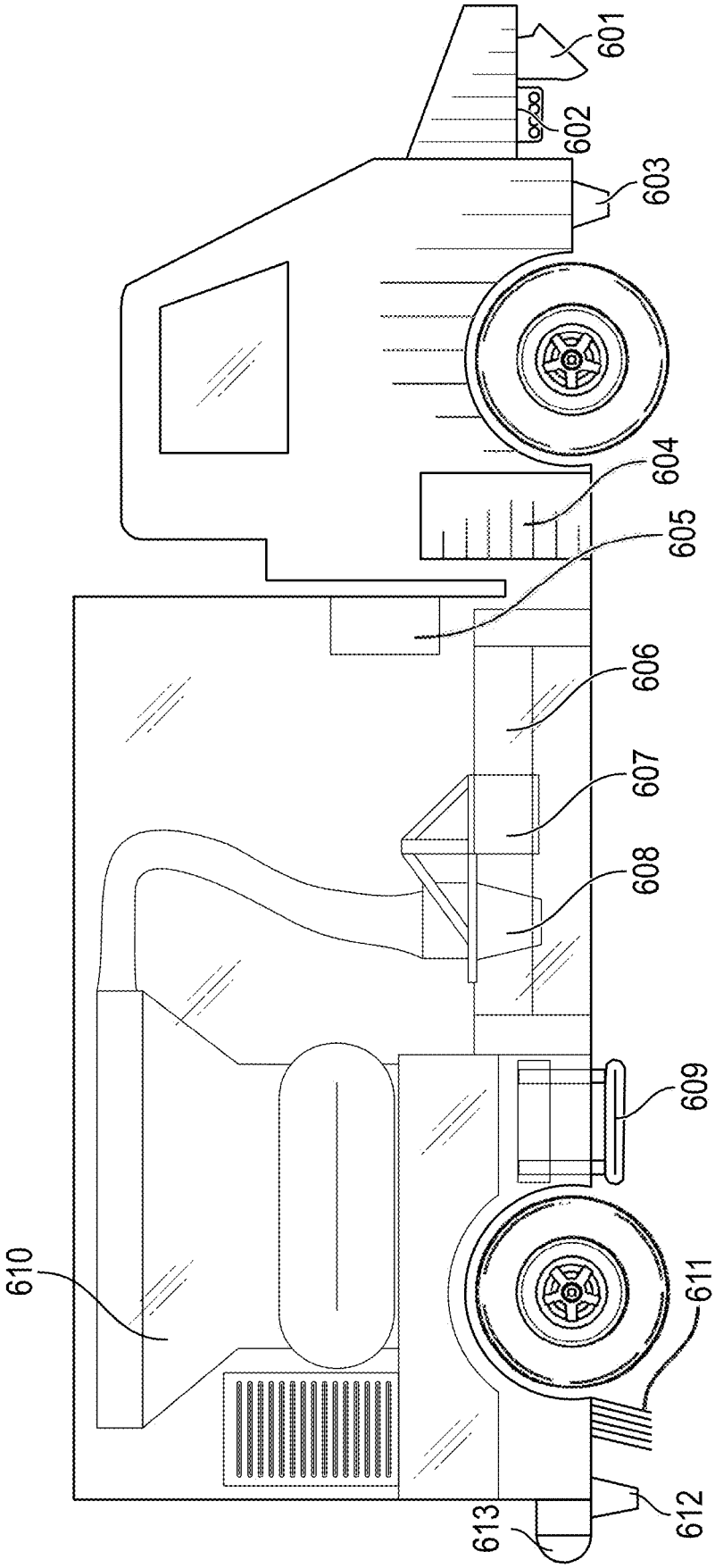


FIG. 6

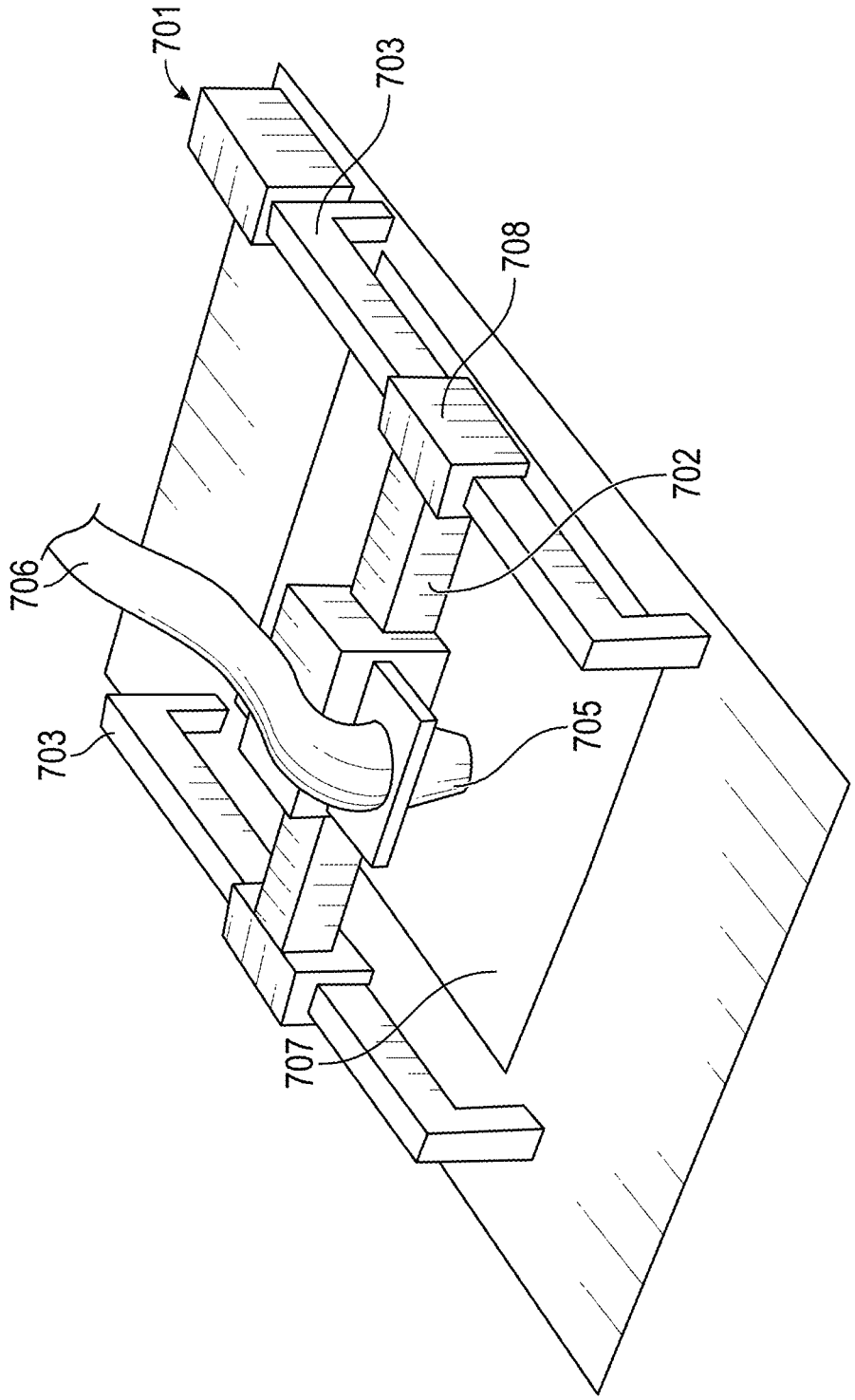


FIG. 7

MOBILE ROAD SURFACE TREATMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. § 120 of U.S. Provisional Application Ser. No. 63/606,945 filed on Dec. 6, 2023 entitled Mobile Road Surface Treatment System, the content of which is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

[0002] Conventional road maintenance and pavement treatment vehicle systems generally incorporate material storage apparatus and dispersion apparatus that are designed to operate as a self-contained unit. Conventional pavement treatment vehicle systems require a temporary stoppage of the system while the dispersion apparatus perform its function, with the subsequent surface maintenance functions performed in a separate action.

[0003] Typically, a vehicle is driven to an area adjacent to a pothole in the road, wherein the pothole location is identified previously through another surveying sequence. The vehicle would need to be halted to survey the actual size and depth of the pothole, such that the proper amount of material and appropriate process can be identified through a variety of components either on the vehicle system or in a separate apparatus. There are various methods of mending the pothole, wherein different devices would be implemented on each vehicle system to facilitate the treatment.

[0004] Some methods can be implemented through deposition and smoothing of material within the pothole, while other methods would require cutting the surrounding pavement material as a part of its process. Some methods require the vehicle to clean the pothole surface with equipment such as a blower to remove debris before proceeding with the repair. Tack stored within the vehicle system is then sprayed into bottom of the pothole, wherein the tack is kept in place through adhesion material or moisture activated material. Asphalts or other common road repair material is then heated up before depositing into the pothole, thereafter the road repair material is flattened by a separate rake device and tampered through a roller or tamper device. Alternatively, a human operated or mechanically operated boom structure can be implemented on the vehicle such that localized deposition can be performed without having to reposition the vehicle during the process.

[0005] In all conventional methods, the pavement treatment steps require the vehicles to be halted completely. In dense urban areas where traffic cannot afford to be interrupted, conducting road repairs and pavement treatment during normal commute hours would cause significant disturbance. As an alternative, road repair operations would need to be scheduled during off hours, thereby putting strain on the workers and community noise. Therefore, there exists a need to a system to perform pavement maintenance in motion alongside traffic to maximize efficiency and minimize disturbance.

SUMMARY

[0006] The following summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

[0007] In various implementations, a mobile road surface treatment system is provided. The system comprises a control module, a scanning module configured to detect a road cavity, and a material extrusion device mounted on a gantry on a vehicle configured to travel at a moving speed and moving direction. The system may be configured such that the control module instructs the material extrusion device to move on the gantry to hover above the road cavity and deposit repair material into the road cavity, corresponding to the moving speed and moving direction.

[0008] In various other implementations, a mobile road surface treatment system is provided. The system comprises a material extrusion module connected to a material preparation unit on a gantry comprising at least an X-axis member and a Y-axis member, wherein the material extrusion module is configured to move along the X-axis member and Y-Axis member, a scanner module configured to detect a road cavity, and a control module on a vehicle having a moving speed and moving direction. The scanner module generates a geometric code for the road cavity, and the controller instructs the material extrusion module based on the geometric code to direct the material extrusion module to move along the X-axis member and Y-axis member and remain in a position above the road cavity. the material extrusion module deposits a repair material from the material preparation unit while the extrusion module hovers in the position.

[0009] In various other implementations, a mobile road surface treatment system is provided. The system comprises a control module on a vehicle, a scanner at front end of the vehicle, a preparatory apparatus installed on the vehicle proximately behind the scanner, a material handling apparatus, configured to contain and maintain road fill compound, installed on cargo bearing section of the vehicle, a plurality of cameras installed on perimeter of underside of the vehicle, a repair unit comprising a deposit module installed on a plurality of unit guide rails, wherein the unit guide rails are movably connected to one another, and a post repair module. The system is configured such that the vehicle is configured to travel at a moving speed and a moving direction. The control module is configured to receive input from the scanner, the plurality of cameras, and the vehicle and generates an instruction to the preparatory apparatus, the material handling apparatus, and the repair unit. The instruction controls the preparatory apparatus to remove debris from a pothole. The instruction controls the repair unit to move on the plurality of unit guide rails in corresponding speed to the moving speed and corresponding direction to the moving direction. The instruction controls the material supply apparatus to supply the road fill compound to the deposit module. The deposit module deposits the road fill compound into the pothole, and the post repair module renders the road fill compound into a flat condition in the pothole.

[0010] In various other implementations, a method for maintaining road surface on a moving vehicle is provided. The method comprises providing a vehicle with a scanner module, a control module, and a material extrusion module mounted on a gantry; driving the vehicle to travel at a moving speed and a moving direction; detecting a road cavity with the scanner module and generating a geometric code; generating an instruction with the control module

based on the geometric code, the moving speed, and the moving direction; directing, with the instruction, the material extrusion module to move along the gantry, such that the material extrusion remains in a position above the road cavity; and depositing a repair material through the material extrusion module while the extrusion module hovers in the position.

[0011] In various other implementations, a method for maintaining road surface on a moving vehicle is provided. The method comprises driving the vehicle with a scanner, a plurality of cameras, a preparatory apparatus, a material handling apparatus, a repair unit, and a post repair module, to travel at a moving speed and a moving direction. The method further comprises transmitting input from the scanner, the plurality of cameras, and the vehicle, and then generate an instruction to the preparatory apparatus, the material handling apparatus, and the repair unit. The instruction is to instruct the preparatory apparatus to remove debris from a pothole, instruct the repair unit to move on a plurality of unit guide rails in corresponding speed to the moving speed and corresponding direction to the moving direction, and instruct the material supply apparatus to supply the road fill compound to the deposit module. Thereafter, the instruction commands to deposit the road fill compound into the pothole and render the road fill compound into a flat condition in the pothole.

[0012] These and other features and advantages will be apparent from a reading of the following detailed description and a review of the appended drawings. It is to be understood that the foregoing summary, the following detailed description and the appended drawings are explanatory only and are not restrictive of various aspects as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a block diagram of a mobile road surface treatment system in accordance with the subject disclosure.

[0014] FIG. **2** is an overhead view of a mobile road surface repair system in accordance with the subject disclosure.

[0015] FIG. **3** is an exemplary process in accordance with the subject disclosure.

[0016] FIG. **4** is an exemplary block diagram of software modules in accordance with the subject disclosure.

[0017] FIG. **5** is a sideview of a mobile road surface repair system with a custom extrusion module in accordance with the subject disclosure.

[0018] FIG. **6** is a sideview of a mobile road surface repair system with a trailer loaded custom extrusion module in accordance with the subject disclosure.

[0019] FIG. **7** is a perspective view of a motion controller module of the mobile road surface repair system in accordance with the subject disclosure.

DETAILED DESCRIPTION

[0020] The detailed description provided below in connection with the appended drawings is intended as a description of examples and is not intended to represent the only forms in which the present examples can be constructed or utilized. The description sets forth functions of the examples and sequences of steps for constructing and operating the examples. However, the same or equivalent functions and sequences can be accomplished by different examples.

[0021] References to "one embodiment," "an embodiment," "an example embodiment," "one implementation," "an implementation," "one example," "an example" and the like, indicate that the described embodiment, implementation or example can include a particular feature, structure or characteristic, but every embodiment, implementation or example can not necessarily include the particular feature, structure or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment, implementation or example. Further, when a particular feature, structure or characteristic is described in connection with an embodiment, implementation or example, it is to be appreciated that such feature, structure or characteristic can be implemented in connection with other embodiments, implementations or examples whether or not explicitly described.

[0022] References to a "module", "a software module", and the like, indicate a software component or part of a program, an application, and/or an app that contains one or more routines. One or more independently modules can comprise a program, an application, and/or an app.

[0023] References to an "app", an "application", and a "software application" shall refer to a computer program or group of programs designed for end users. The terms shall encompass standalone applications, thin client applications, thick client applications, mobile-based applications, web-based applications, such as a browser, and other similar applications.

[0024] Numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments of the described subject matter. It is to be appreciated, however, that such embodiments can be practiced without these specific details.

[0025] The subject disclosure is directed to a mobile road surface repair system that can detect, prepare, and repair damaged road surfaces in a process while in motion. Damaged road surfaces can take the form of potholes, road cavities, abrasions, erosions, etc. Any of the road surface condition damages can be used interchangeably in the subsequent description. Conventional road surface repair methods require multiple passes through the pothole area, as multiple systems may be required to assess the need and carryout the repair. The mobile road surface repair system is intended to identify the repair area, prepare the material for repair, and finish the repair during one sequence of event. The subsystems and components of the mobile road surface repair system does not require the system to halt in traffic, as all functions are performed while the vehicle is in motion. The road surface repair system permits minimal disruption in traffic flow in the surrounding area, thus eliminating potential obstructions and interruptions to congested areas.

[0026] The mobile road surface repair system may comprise a scanner on a front end, such that road surface conditions can be surveyed continuously. The scanner may be configured to identify parameters pertinent for repair, including but not limited to width, depth, surface area topography, debris and foreign objects identification, and volume of repair. Once a road condition, such as a pothole or a road cavity, is detected, the scanner may be configured to provide the parameters to a central processing unit on board of the mobile road surface repair system. The central processing unit enables subsystems and components on the mobile road surface repair system to function in motion, while taking into account the traveling speed, direction, velocity, and pattern of the system. In various implementations, the mobile road surface repair system maintains an

even speed during operation, such that continuous movement eliminates a need for keeping surround traffic in a halted state.

[0027] A surface preparation apparatus may be implemented in close proximity to the scanner, such that road condition may be prepared prior to the repairing process. The surface preparation apparatus may comprise an airflow device that enables vacuum or blower functions. Should the scanner detect loose debris within the road condition, the surface preparation apparatus may remove the loose debris through the air flow device. The surface preparation apparatus may be configured to operate while matching the truck with an average pace.

[0028] A material supply apparatus may be implemented on the mobile road surface treatment system to subsequently carryout the pothole or cavity filling function of the road surface repair process. The material supply apparatus may be implemented to handle tack, cold asphalt, asphalt milling, etc. The material supply apparatus may comprise an extrusion device that is custom designed for the dimension and application requirement of each mobile road surface treatment system. The material supply apparatus may be integrated into the mobile road surface treatment system. Alternatively, the material supply apparatus may be installed on an attachment module that is connected to the mobile road surface treatment system.

[0029] As the scanner identifies the parameters of the road condition such as a pothole or cavity, the central processing unit may direct the material supply apparatus to apply an appropriate amount of road repair material into the cavity. In various embodiments, the material supply apparatus includes be designed to keep tack and road fill compound material in ready-to-use conditions, such that pothole or cavity filling material can be deposited while the system is in motion without significantly advanced notification. The material supply apparatus may incorporate vibration, rotation, and/or heating elements to ensure material readiness while the mobile surface repair system is in transit.

[0030] The material supply apparatus may be implemented to maintain its orientation with the road condition while the vehicle is in motion. This may be achieved by having a deposit device or repair unit attached to the material supply apparatus, wherein the deposit device may move in a manner that correspond to the traveling speed and direction of the vehicle. The material supply apparatus may be configured to have the deposit device installed on a gantry or rail structure on the vehicle of the mobile road surface treatment system, such that the deposit device may move at the same speed as the vehicle in the opposing direction. Altogether, the deposit device may be positioned on top of the road condition through the entire movement of the mobile road surface treatment system. The central processing unit may provide real time data processing and instruction generation, such that the location of the cavity relative to the vehicle may be analyzed continuously. In various situations, the deposit device may be directed to maintain a position directly above the road cavity in a steady fashion as the vehicle continuous to move forward. The deposit device may in turn move along the gantry or rail system while matching speed of the vehicle traveling forward. In various embodiments, the gantry or rail system may provide horizontal as well as vertical motion support in order to account for more varied vehicle travel patterns.

[0031] The central processing unit may be configured to accept input from the vehicle regarding its travel speed, direction, and pattern, such that an algorithm may be implemented to generate instructions to the deposit device accordingly. In various embodiments, the mobile road surface treatment system vehicle may be oriented such that the area designated for the deposit device is going to cover the location of the road cavity during the vehicle's travel. The central processing unit may obtain the location of the road cavity from the scanner in the front and issue an instruction to position the deposit device to align with the road cavity. The position of the deposit device relative to the vehicle may be adjusted based on the vehicle's relative position to the road cavity, and adjustments may be made along the horizontal or vertical rails on the vehicle.

[0032] The area designated for the deposit device may be monitored through a plurality of detection devices along the underside of the mobile road surface treatment system vehicle to ensure that the deposit device is aligned with the road cavity during the vehicle's travel. Upon the road cavity's entry into the area designated for the deposit device, the central processing unit may continuously provide input for the deposit device to be moved along its positional rails on the gantry to ensure consistent alignment. An artificial intelligence or machine learning based algorithm may implemented so that the instructions can be generated to accommodate predicative or real time event changes.

[0033] The deposit device may be configured to supply road repair material into the road cavity at a rate that is consistent with the travel speed of the vehicle. Thus, the central processing unit may adjust the deposit rate, such that the road cavity may be fully filled prior to the cavity's position surpasses the area designated for the deposit device. In various embodiments, the deposit device may be coupled with a material handling subsystem in order to supply road paving material that is primed for repair. As such, heating element and rotation elements may be incorporated with the material handling subsystem, such that the road paving material may be maintained in the ideal consistency during the material deposit operation.

[0034] In various implementations, the mobile road surface treatment system may utilize any material that is suitable to the operation. In one embodiment, the material may be asphalt. In at least one other embodiment, the material may be cold composite that does not require temperature control to maintain the consistency. It is foreseeable that a person skilled in the art may adapt the mobile road surface treatment system to accommodate any material that is appropriate for each specific application.

[0035] The continuous monitoring and management of the deposit device while the road cavity is within the area designated for the deposit device may allow the road cavity to be filled while the mobile road surface repair system is in motion. As most of the conventional road repair system requires a deposit device to be in a fixed position, road repair would cause disruption to traffic during operation. Comparatively, the mobile road surface repair system may provide the road repair function while the vehicle is in transit, thus eliminating needs for any stoppage in traffic.

[0036] In the exemplary embodiment, the deposit device may be configured to fill one road cavity per pass. In various other embodiments, multiple deposit device may be configured to provide multiple road repair instances per pass. Alternatively, each deposit device may be adjusted to fill the

road cavity at variable rate, such that one single deposit device may be instructed to complete filling of multiple road cavities during a passthrough. Further, the deposit device may be configured to continuously and readily locate to the subsequent road cavities during the vehicle's travel, such that multiple road cavities along a stretch of the road may be repaired continuously by the mobile road surface treatment system.

[0037] One goal of the mobile road surface treatment system may be to enable road cavity repair without halting the system, so the rate at which the deposit device supplies the filling material may be varied. In one implementation, the central processing unit may calculate a deposit rate for the deposit device based on the condition of the filler material and the velocity of the vehicle. The central processing unit may take into consideration the condition of the filler material, such as consistence, viscosity, and temperature, such that the filler material may be distributed evenly during the process. The spray rate would affect the formation of the filler layer within the road cavity, so it will be balanced against the velocity of the vehicle. While the vehicle does not need to be halted for the mobile road surface treatment system to perform its function, the vehicle's speed may affect the rate that the filler material is distributed into the cavity of the road. Therefore, the mobile road surface treatment system may continuously monitor the velocity of the vehicle to manage spray rate of the deposit device.

[0038] In various implementations, surface care devices may be configured onto the mobile road surface treatment system to provide comprehensive cavity repair services. In exemplary embodiments, a rake and a roller may be affixed at rear end section of the vehicle of the mobile road surface treatment system. The rake may gather and collect excessive filler material as the vehicle passes above the cavity after the deposit device has completed its function. In various embodiments, the rake may be implemented with an optional scoop to collect and recycle the excess material. The excess material may be collected into the filler material storage on board the mobile road surface treatment system in an exemplary embodiment. Further, a roller may be implemented to make compact the filler material within the road cavity, thus eliminating needs for a separate device or service session to care for the newly repaired road cavity. In various implementations, a tamping device may be used to smoothen the surface produced by the repair material in the newly repaired road cavity. The central processing unit may be configured to provide instructions to the vehicle and/or the surface care devices to optimize the surface care performance. The velocity of the vehicle, the temperature and characteristic of the filler material, and the condition of the surface care devices may all be taken into consideration to minimize variation of vehicle travel, thus minimizing disruption to the surrounding traffic.

[0039] The deposit device may be configured to have a variety of heads or attachments. Depending on the filler material chosen for specific road settings, different filler methods may be enabled by the deposit device. In some embodiments, the filler material may be distributed into the road cavity as a singular column, wherein the filler material may naturally disperse into an even distribution. In various embodiments, a wide spray head may implemented to enable a larger distribution rate. In further embodiments, additional components may be implemented on the deposit device to enable concurrent treatment of the filler material during deposit processes, including heating element or guided distribution modules. The deposit device may comprise a spray mechanism designed to supply filer material in an evenly distributed fashion. It is understood that filler material selection would affect the configuration of the deposit device, such that specific spray heads can be utilized to accommodate specific application requirements. A person skilled in the art may modify the deposit device to accommodate specific road repair needs based on the preceding disclosure.

[0040] In various embodiments, the mobile road surface treatment system may be implemented to operate off course. In various implementations, the central processing unit may obtain travel route from existing databases as well as through input devices in real time, which allows the central processing unit to prepare the deposit device to accommodate specific speed determinations. In certain situations, an operator onboard may decide to steer the vehicle onto routes that are not previously planned. In order to facilitate flexible functionalities, the mobile road surface treatment system may be configured to make real time survey of the road surface on the newly traveled road, such that contemporaneous calculations may be carried out to repair road cavities that may be encountered. This provides flexible operation options, such that a road care crew may perform preemptive survey and repair without relying on pre-planning. This level of flexibility may thus further decrease the potential trips needed to maintain roads in an area.

[0041] Various features of the subject disclosure are now described in more detail with reference to the drawings, wherein like numerals generally refer to like or corresponding elements throughout. The drawings and detailed description are not intended to limit the claimed subject matter to the particular form described. Rather, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the claimed subject matter.

[0042] Now referring to the drawings and particularly to FIG. **1**, various features of the subject disclosure are now described in more detail with respect to a mobile road surface treatment system. The mobile road surface treatment system is generally designated as **100**, which may be implemented as a standalone vehicle **111** or as an attachment to existing vehicles **111**. A central processing unit may be incorporated into the vehicle **111**, wherein data analysis, operating management, and instruction commands may be carried out without external networks. Alternatively, a transceiver module may be implemented to connect the road surface treatment system **100** to a computing network, wherein instructions may be provided to the system **100** through external sources. The mobile road surface treatment system comprises a vehicle **111** with a scanner **103** located on the front end. A repair unit **101** is positioned in the middle section **112** of the vehicle **111**, which may be a bed, or a trailer, towed by a truck. The repair unit **101** may be mounted on a series of unit guide rails **102**, which allow flexible movement while the mobile road surface treatment system is performing road filling functions. A number of cameras **104** are positioned around the perimeter of the vehicle **111**, outlining area of operation accessible by the repair unit. A material supply apparatus may be connected to the repair unit **101** and may be configured to hold road compound fill and/or tack fill. In operation, the unit motion extracts road compound fill from the material supply appa-

ratus, which may be configured to keep the road compound fill in ready to use conditions.

[0043] The scanner **103** may be configured to identify the damaged sections of the road while the vehicle **111** is traveling along a path on the road. In various embodiments, the scanner **103** may be configured to evaluate the size, depth, angle, and volume of the damaged road area **191** in motion. The scanned information may be provided to a central controlling unit within the vehicle **111**. Alternatively, the scanned information may be provided to a cloud computing network, optionally in relation to Global Positioning System (GPS) and Geographic Information System (GIS), wherein further analysis may be performed, and instructions may be generated. In an exemplary embodiment, the road repair system **100** may be driven to follow a predetermined route as a part of preventative maintenance, such that the scanner **103** enables the system **100** to make real time road repair decisions. The scanner **103** may be coupled to confirm previously conducted road surface surveys, such that the system **100** may be utilized to provide accurate repair responsively.

[0044] In various embodiments, a road condition preparation module may be positioned shortly after the scanner **103**. In an exemplary embodiment, the road condition preparation module may be in the form of a plurality of air blowers. When the pothole **191** is filled with debris, it would be prudent to remove such debris before the filling operation in order to ensure maximum adhesion of the filler material. Therefore, the plurality of air blowers may remove the excessive debris within the pothole **191** as the vehicle **111** moves past. In various other implementations, drying mechanisms, scoop mechanisms, and other relevant physical removal mechanisms may be configured to provide optimate preparatory condition for the pothole **191**.

[0045] A plurality of cameras **104** are positioned around perimeter of the road repair system **100**. Each camera is configured to monitor a section of the area under the vehicle **111** and assist in maintaining real time update to the road repair operation. The cameras **104** and the scanner **103** combine to provide a comprehensive visualization of the road surface when the vehicle **111** navigates through the street, wherein the central processing unit or the connected computing network may utilize the visualization to conduct precise analysis and responsive instructions to other components of the road repair system **100**.

[0046] The road repair system **100** comprises at least one material supply apparatus **112**, wherein road compound fill and/or tack fill are stored. In an exemplary embodiment, a section of the material supply apparatus **112** may be designated for tack fill. A plurality of tack fill nozzles may be positioned around the bottom of the vehicle to apply the tack on the road cavity **191**, if necessary. Another section of the material supply apparatus **112** may be designated for road compound fill. The material supply apparatus **112** may be configured to accommodate a number of common road compound fill, such as cold asphalt patch, asphalt millings, concrete, etc. Material handling mechanisms are implemented on the material supply apparatus **112** to ensure that the road compound fill is at the right consistency for optimal filling operation. Such material handling mechanisms may include rotational devices, heating elements, mixing devices, etc. Should the material be prepared in advance to being applied by a repair unit **101**, the central processing unit or cloud computing network would issue instructions to the material handling mechanisms during the vehicle **111**'s transit. The preparatory period may thus be shortened to further support the mobile road surface repair system **100***s* ability to repair damaged road surfaces without stopping in traffic.

[0047] The deposit module or repair unit **101** may be installed on a system of unit guide rails **102** underneath the vehicle **111**. The unit guide rails **102** may be implemented in close proximity to the material supply apparatus **112** to ensure consistent material supply to the repair unit **101**. The unit guide rails may comprise of at least one horizontal and one vertical rail, wherein the repair unit **101** may navigate according to its position to the road cavity **191**. The unit guide rails may further be moved along axis that are parallel or perpendicular to the edge of the material supply apparatus **112**. The motion of the repair unit **101** along the unit guide rails **102** is further illustrated in FIG. **2**.

[0048] In FIG. **2**, an overhead view of the mobile road surface repair system **100** is provided. A filling operation area **210** may be designated within parameter of the vehicle for the repair system **100**. Within the filing operation area **210**, a horizontal (or parallel) unit guide rail **202** may be mounted in intersection with a vertical (or perpendicular) unit guide rail **203**. The parallel unit guide rail **202** and the perpendicular unit guide rail **203** may be implemented such that each rail may move along the joined rail, such that the combined movements may provide coverage for the entire area **210**. A repair unit **201** may be mounted on the parallel unit guide rail **202** in the exemplary embodiment. In alternative embodiments, the repair unit **202** may be mounted on the perpendicular unit guide rail **203**. In either implementation, the repair unit **201** may be installed to enable movement along the unit guide rail that it is connected to. Thus, while the repair unit **201** may move along the length of the parallel unit guide rail **202**, the unit guide rail **203**'s movement along the perpendicular unit guide rail **203** allows the repair unit **201** to be positioned in additional axis. The central processing unit on board the vehicle would instruct the movements of the repair unit **201** as well as the unit guide rails. Together, this allows the repair unit to provide continuous coverage of a pothole on the ground as the vehicle drives over. The central processing unit would take into account the position of the pothole in relation to the vehicle and direct the repair unit **201** to maintain a fixed position over the pothole, while moving at a speed matching that of the traveling vehicle.

[0049] Returning to FIG. **1**, a person skilled in the art may recognize that the repair unit **101** may hover over the pothole **191** within the right parameters. The vehicle's travel direction and speed may be analyzed by the central processing unit onboard the vehicle **111**, and the corresponding direction and speed may be instructed to the repair unit **101**. Therefore, when the vehicle **111** travels over the pothole **191**, a path of travel for the repair unit **101** along the unit guide rails **102** may be plotted out by the central processing unit, such that the repair unit continuously deposit road compound fill into the pothole **191**. The central processing unit or the cloud computing network takes into account inputs received from the cameras **104**, the vehicle **111**'s own built-in sensors, and material detecting sensors within the material handling apparatus **112** to generate a set of instructions to the repair unit **101**, wherein the repair unit **101** deposits road compound fill into the pothole **191** at a specific rate. The combined motion of the repair unit **101**, unit guide

rails **102**, and the vehicle **111** ensures that the pothole **191** may be filled while the entire mobile road surface treatment system **100** is in motion. This eliminates needs for a complete stoppage of the mobile road surface treatment system **100** in order to complete the filling operation, thus drastically minimize potential disruption to existing traffic.

[0050] The plurality of cameras **104** may be used to further monitor the operation of the repair unit **101** in real time. The central processing unit may be configured to identify abnormalities in the repair unit **101** in order to make responsive adjustments. Should the repair unit **101** move out of the position of the pothole **191** for any reason, commands may be provided to the repair unit **101** and the unit guide rails **102** to correct the motion.

[0051] The central processing unit or the connected cloud computing network allows the mobile road surface treatment system to exert precise and constant control of the road filling function during the process. In various implementations, algorithms may be implemented to issue automatic commands upon certain inputs from the scanner **103** or the cameras **104**. Artificial intelligence or machine learning methodologies may be utilized to enhance the repair process. Road conditions, road maps, historic surveys, and previous operation records, etc. may be utilized to train the algorithm to further enhance the operation performance.

[0052] While the mobile road surface treatment system **100** utilizes various forms of asphalt to fill the pothole **191** in this exemplary embodiment, alternative materials may be used in conjunction with varying deposit attachment on the repair unit **101** to facilitate a variety of road repair functions. In one alternative implementation, self-forming concrete may be utilized to produce flat road surfaces without additional condition maintenance measures. In various other implementations, the repair unit **101** incorporates mechanical attachment that would aid in formation of the pothole filling in order to decrease filling time of each pothole **191**, such that multiple potholes may be filled consecutively without stopping or slowing down the vehicle **111**.

[0053] In an exemplary embodiment, a number of maintenance modules are implemented after the repair unit **101** in order to provide the necessary aftercare for a pothole filling. A series of rake or brush implements may be configured immediately after the filing operation area, as indicated by the filing operation area **210** in FIG. **2**. The rake and brush implements provide immediate conditioning for the newly filled road compound fill in order to ensure an acceptable level of smoothness on the pothole. In various implementations, the rake and brush may be implemented on additional unit guide rails to provide responsive and accurate road filling aftercare.

[0054] In addition, a plurality of rollers may be implemented as part of the road condition and maintenance modules. The rollers may provide the necessary impact and compounding force to apply consistency to the road compound fill. The rollers act as the final step in forming the filler material in the appropriate formation within the road cavity **191**. In various implementations, a tamping device may be used to smoothen the surface produced by the repair material in the road cavity **191** . . . . As such, the pothole **191** may be fully filled in one pass through by the vehicle **111** without requiring any additional stoppage or blockage in traffic.

[0055] In various implementations, the mobile road surface treatment system **100** may be configured to make multiple pothole repairs in motion. The controlling modules such as the central processing unit or the computing network may analyze multiple potholes detected by the scanner **103** and instruct the repair unit **101** and the unit guide rails **102** to respond to numerous potholes while in motion. Varying material deposit rate may be calculated to speed up certain filling process to allow sufficient time for the repair unit **101** to move into the next location for subsequent fillings. A person skilled in the art may make modifications to enable the mobile road surface treatment system **100** to perform multiple repairs consecutively or concurrently.

[0056] The mobile road surface treatment system **100** may be used as a part of a system to support predicative analysis of road conditions. As the mobile road surface treatment system **100** conducts road repair operations and transmits data to a server through the cloud computing network, a database may be populated with pattern of road damage within a certain geographic area. Such data may be trained in machine learning methodologies to anticipate repair requirements in the future. A plurality of mobile road surface treatment systems **100** may further be used to provide a wide road condition survey in an area, thus providing important planning and scheduling insight for maintenance departments in cities, municipalities, counties, and states.

[0057] Referring to FIG. **3**, a process for utilizing the mobile road surface treatment system is provided. The illustrated process may be adapted to be used with a variation of a mobile road surface treatment system as disclosed herein. At **301**, the process starts with identifying a road cavity or pothole with a scanner on a vehicle moving at a steady pace. Viewed in conjunction with the preceding description, the scanner may be configured to operate with real time image recognition. Information regarding the specific roads from previous surveys may be used in conjunction to confirm the accuracy of the scanner.

[0058] At **302**, the traveling velocity of a repair unit or cavity filling module is analyzed with a controller. The controller may be a central processing unit onboard the vehicle or a cloud computing network. The repair unit is mounted on a series of unit guide rails to enable corresponding movement in response to the vehicle. This enables the repair unit or cavity filling module to remain aligned with the road cavity as the vehicle continues in its travel, thus enabling continuous road repair without stopping the vehicle.

[0059] At **303**, cavity filling material is deposited through the cavity filling module as the vehicle moves over the road cavity or pothole. Included in this step would be any preparatory steps necessary to ensure the pothole surface is ready for the road compound fill. The controller, central processing unit, or cloud computing network responsible for controlling the repair unit may also adjust the deposit rate, such that the pothole may be filled when the vehicle passes through in one motion. Alternatively, increased deposit speed allows the repair unit to quickly fill multiple potholes in succession.

[0060] At **304**, the filling process is monitored through cameras located along the perimeter of the vehicle. Adjustment to the positioning of the cavity filling module is enabled should any deviations, abnormalities, or mistakes are identified by the visual monitoring devices.

[0061] At **305**, the newly filled road cavity is maintained by auxiliary road care modules as the vehicle passes over. Such auxiliary road care modules may include brushes,

rakes, and/or rollers, to ensure that the road filling is smoothened and condensed at the end of the filling operation. This ensures that the repair system may complete the filling function without repeating visit to the same location.

[0062] During the process, the mobile road surface treatment system may be paused at any time either manually or automatically. A user may determine a stoppage is necessary and manually pause or terminate the preceding cycle. In various implementations, the mobile road surface treatment system may detect abnormalities during the process that requires an emergency stop and pause the repair process. In various implementations, the repair module may be paused and/or retracted while the vehicle is in motion. Alternatively or concurrently, the mobile road repair vehicle may be stopped entirely.

[0063] After the preceding cycle has finished on the repair effort, the mobile road surface treatment system may continue with traveling on the road. Upon detecting another cavity on the road surface ahead, the mobile road surface treatment system may repeat the process illustrated **301-305**. Each of the repair effort may be logged in the central processing unit, which may transmit the repair data to a remote database. The mobile road surface treatment system's travel path may thus be logged alongside the repair efforts, wherein records of the road surface repair needs may be generated for any particular road. Additionally, should the mobile road surface treatment system determine that a repair effort was insufficient, the position and condition of the road cavity may be transmitted to other vehicles in the fleet to facilitate supplemental repair efforts.

[0064] In various implementations, the process described in **301-305** may be scheduled for periodic operations. A fleet of mobile road repair vehicles may be configured to carry out the road repair process according to a database of road conditions data from previous cycles, wherein the resulting output may be analyzed and relied upon to prompt the subsequent cycles. In various implementations, the entire process **301-305** may be automated.

[0065] Referring to FIG. **4**, an implementation of the software behind the mobile road surface treatment system may be compartmentalized into five modules. The first module may be configured to facilitate functions of pothole detection.

[0066] Pothole detection may be operated by a lightweight computer. In various examples, the lightweight computer may be implemented similarly to a Raspberry Pi or NVidia Jetson. A person skilled in the art may adapt the lightweight computer in any comparable computer implementations. The lightweight computer may utilize a camera module to view the environment ahead of the vehicle, such as the scanner **103** in FIG. **1**. This video data may then be fed to a computer vision model trained to detect potholes. Once a pothole is detected, a signal may be sent to the next module where three-dimensional data is gathered. The software modules may be configured to calculate excess contents within the road cavity, such as water, leaves, debris, etc.

[0067] Next, a module may be utilized for the creation of a three-dimensional model of the pothole. To gather this information, a Light Detection and Ranging (LiDAR) sensor may be used, comprising a LIDAR Scanning module. The LiDAR scanning module may emit lasers and records the time it takes the laser to return to calculate distances from the road cavity to the mobile road surface treatment system. By repeated this process across large areas, three-dimensional information may be interpolated from the LiDAR scans. Once a pothole is detected by the detection module, the LiDAR may utilize scanned data to create two or more models of the road cavity. Since the vehicle is constantly moving, a second model may be necessary to account for the movement of the vehicle. The LiDAR Scanning module may be coordinated with a central processing unit to adjust model creation based on the travel speed and direction of mobile road surface treatment system.

[0068] Upon completion, models created by the LiDAR scanning module may be sent to a server for conversion. In various implementations, the LiDAR Scanning module may create three-dimensional models as point clouds (a collection of points and their positions in space), which may be converted into relevant file formats to be utilized by the gantry on mobile road surface treatment system. In an exemplary process, the point cloud may be converted by the server into a mesh. Unlike a point cloud, a mesh uses planes and edges to connect all the points into a single continuous object. Once a mesh is created, the road cavity may then be isolated from the environment clearly, which may be generated as an output for the subsequent modules within the server.

[0069] The output comprising the isolated and converted road cavity model may undergo a "slicing" process to be converted into instructions for the gantry system. Slicing, in this example, may refer to the operations that take a 3D model and produce machine code for the gantry system. Slicing algorithms may vary to a great degree across platforms and gantry systems, and the mobile road surface treatment system may adopt specific slicing algorithms to accommodate the specific gantry component configuration.

[0070] The machine code may be sent to the gantry system, which may comprise a gantry controller. The gantry controller may receive the machine and move the gantry accordingly. The gantry controller may comprise 3 motor controller in an exemplary implementation. The first and second may control the x and y axis motors, which may move the extrusion system over the road cavity as the vehicle continues in its motion. The third motor controller may be configured to control the actuation of the extrusion system. During the generated path of the extrusion system, the third motor may operate the extrusion between off and on state deploy repair material into the road cavity with appropriate flow rate.

[0071] In various implementations, the server may be configured to determine whether a road cavity is too deep or too wide for the capacity of the mobile road surface treatment system, either in a single passing or altogether. The server may be configured to transmit the road cavity analysis to other mobile road surface treatment systems in the fleet, wherein multiple vehicles may be deployed to address any road cavity that may not be repaired in one pass by one vehicle. Similarly, the server may be configured to coordinate consecutive or concurrent repair efforts by multiple vehicles. Should the mobile road surface treatment system determine that a repair cycle has not been sufficient, the repair status and condition of the particular road cavity may be transmitted to other vehicles of the fleet for supplemental repairs.

[0072] In various implementations, the software on the mobile road surface treatment system may be configured to generate a deliverable to users. The software may generate pictures, videos, heat mapping, project image mapping, etc.

associated with the road repair processes, which may be accessed by users through a user interface. The user interface may be managed by users and the access may be provided to third party clients.

[0073] In various implementations, a user interface module may be implemented to provide update and access to status of the road repair process. In various implementations, conditions requiring immediate attention may be alerted to the users through the user interface module in a timely manner. The conditions may comprise overheating, obstruction, material shortage, or malfunctions of components.

[0074] Referring to FIG. **5**, an embodiment of the mobile road surface treatment system **500** is shown with a custom extrusion module **510**. The mobile road surface treatment system **500** comprises a road condition preparation module **501**, including an air blower or vacuum. The road condition preparation module **501** is configured to clean debris and obstructive material from the road cavity to prepare the road condition for optimal repair.

[0075] The mobile road surface treatment system **500** comprises a sensor array **502**. In various implementations, the sensor array **502** may comprise any relevant sensor devices for detecting road cavities, while the vehicle **500** is in motion. The sensor devices may comprise LIDAR, computer vision, camera, and additional sensors as needed. This sensor array **502** scans the road cavity and captures an accurate reading of the road cavity in its "before" state. This sensor array **502** may be a single array located in the front of the vehicle **500**. Alternatively, the sensor array **502** may be spread out in multiple locations along the truck.

[0076] The mobile road surface treatment system **500** may comprise a tack fill module with spray nozzles **503**, which is configured to output tack for hot and warm patch asphalt. In various implementations, the spray nozzles **503** may be configured to output material for road repair utilizing materials other than asphalt.

[0077] The mobile road surface treatment system **500** may comprise a server **504** on board the vehicle. The server **504** may be configured to complete all software tasks for the system **500**, including processing sensor data and outputting geometric code (G-Code) to the motor controllers **505**. At the same time, the motor controllers **505** take the G-Code input from the server and outputs as motor control for the gantry.

[0078] The mobile road surface treatment system **500** may comprise a gantry **506** that controls the motion of the extrusion toolhead **507**. The extrusion toolhead **507** may be configured to deliver payload of road repair material around the gantry **506**. The extrusion toolhead **507** may be configured to connect an extrusion nozzle **508** to the output of the extrusion system **510**. It may also actuate the extrusion itself which will be controlled by the motor controller. The extrusion nozzle **508** may be configured to output the road repair material onto the road below.

[0079] In various implementations, the gantry **506** may be a 2-axis gantry, wherein the extrusion toolhead **508** may be configured to move along the vertical (Y) and horizontal (X) axis relative to the mobile road surface treatment system. The Y-axis (up and down the road) and the X-Axis (left and right across the road) may combine to give full two-dimensional motion across the work area of the gantry **506**. The motor controller will drive the motors on the gantry, which will in turn drive a linear motion mechanism. The linear motion mechanism may be rack and pinion, lead screw, or timing belt.

[0080] In various implementations, the mobile road surface treatment system **500** may comprise an after-treatment module **509**, including a series of rollers or tampers will compact the deposited road repair material (including extruded asphalt) on the road. In various implementations, a dynamic tamping device may be configured to variably tamp down the road repair material, such as extruded asphalt, in accordance to its surface profile. In various implementations, the dynamic tamping device may be configured to coordinate with the gantry and the vehicle traveling velocity. The after-treatment module **509** may comprise individually extending tampers that may conform to the contours of the repair material within the road cavity.

[0081] The mobile road surface treatment system **500** may implement a custom extrusion mechanism **510** to facilitate deposit of road repair material, stored within a storage unit associated with the custom extrusion mechanism **510**, onto the road cavity. In various implementations, the custom extrusion mechanism may be configured to use mechanical pressure, or air pressure, or auger driven extrusion, or any combination of these mechanisms to extrude road repair material out to the extrusion toolhead. In this example, the custom extrusion mechanism **510** may comprise a direct drive extrusion system.

[0082] The mobile road surface treatment system **500** may comprise a smoothening module **511**, which may comprise a brush or rake. This smoothening module **511** may comprise a vacuum or blower that will remove excess asphalt from the road.

[0083] In an implementation of the mobile road surface treatment system **500** that utilizes cold patch asphalt, a spray sealer nozzle **512** may be configured to deposit spray sealer. The spray sealer corresponds with the cold patch asphalt to enable a road repair function without the need to warm and maintain the road repair.

[0084] Finally, a postproduction camera **513** may be configure to document condition and progress of the road repair after the mobile road surface treatment system **500** has passed over the road cavity. The postproduction camera **513** may be connected to the server **504** to compare the "before" and "after" image of the road cavity. The server **504** may further compile the road cavity information from the postproduction camera **513** to instruct other road repair vehicles **500** in the fleet for additional repair efforts.

[0085] In various implementation, the mobile road surface treatment system may be a battery driven unit with dedicated function, wherein unit operation speeds may be further optimized for each specific application.

[0086] Referring to FIG. **6**, another embodiment of the mobile road surface treatment system is shown with a trailer mounted custom extrusion module **610**. The mobile road surface treatment system **600** comprises a road condition preparation module **601**, a sensor array **602**, a tack fill module with spray nozzles **603**, a server **604** on board the vehicle. In various implementations, the server **604** may be a networking module that transmits data to a remote server or a cloud computing network.

[0087] The mobile road surface treatment system **600** comprises a gantry **506** that controls the motion of the extrusion toolhead **607**. The extrusion toolhead **607** may be configured to deliver payload of road repair material around

the gantry **606**. The extrusion toolhead **607** may be configured to connect an extrusion nozzle **608** to the output of the extrusion system **610**.

[0088] In various implementations, the mobile road surface treatment system **600** may comprise an after-treatment module **609**, including a series of rollers or tampers will compact the deposited road repair material (including extruded asphalt) on the road

[0089] The mobile road surface treatment system **600** may implement a trailer mounted custom extrusion mechanism **610** to facilitate deposit of road repair material, stored within a storage unit associated with the custom extrusion mechanism **610**, onto the road cavity. In contrast with the system **600** with the custom extrusion mechanism **610**, the trailer mounted custom extrusion mechanism **610** may be decoupled and maintained separately from the mobile road surface treatment system **600**. In various implementations, the custom extrusion mechanism may be configured to use mechanical pressure, or air pressure, or auger driven extrusion, or any combination of these mechanisms to extrude road repair material out to the extrusion toolhead.

[0090] The mobile road surface treatment system **600** may comprise a smoothening module **611**, which may comprise a brush or rake. In an implementation of the mobile road surface treatment system **600** that utilizes cold patch asphalt, a spray sealer nozzle **612** may be configured to deposit spray sealer. The spray sealer corresponds with the cold patch asphalt to enable a road repair function without the need to warm and maintain the road repair.

[0091] Finally, a postproduction camera **613** may be configure to document condition and progress of the road repair after the mobile road surface treatment system **600** has passed over the road cavity. The postproduction camera **613** may be connected to the server **604** to compare the "before" and "after" image of the road cavity. The server **604** may further compile the road cavity information from the post-production camera **613** to instruct other road repair vehicles **600** in the fleet for additional repair efforts.

[0092] Referring to FIG. **7**, a motion controller for the mobile road surface treatment system is shown. The motion controller works with a gantry system (such as the gantry **500** in FIG. **5** and the gantry **600** in FIG. **6**) to direct the material deposit module over the road cavity while the vehicle is in motion. The motion controller's function in combination (and in response) to the vehicle's motion provides a way to deliver road repair services to road cavity without stopping the vehicle. In comparison to conventional road repair systems, the mobile road surface treatment system does not require the vehicle to be parked for the duration of the repair process, nor dose the system require the vehicle to be positioned in any particular configuration. Rather, the mobile road surface treatment system provides a way for the road repair function to be carried out regardless of the vehicle's travel speed and orientation. This is achieved by having a motion controller configured to direct the deposit module on a gantry to facilitate movement in response to vehicle movements.

[0093] In various implementation, the motion controller receives a series of geometric code (G-Code) from the onboard or remote servers, which represent the movement data of the vehicle. The motion controller will concurrently convert the G-Code from the server and output motor commands to the deposit module positioned on the gantry. In various implementations, the deposit module is directed to move in at least 2 axis on the gantry **701**.

[0094] The gantry **701** comprises an X-axis member, which may support left and right motion over the road to accurately fill potholes of varying widths. The motion of the X-Axis will be controlled by motors, which may be enabled via rack and pinion, belt drive, lead screw, or other linear motion mechanism.

[0095] The gantry **701** comprises a pair of Y-axis members, which may comprise two beams on which the x-axis member travels up and down. The motion of the pair of Y-axis members may be controlled by motors via rack and pinion, belt drive, lead screw, or other linear motion mechanism.

[0096] The motion controller **700** may comprise an extruder tool head **704**. This tool head **704** may travel along the X-axis member **702**, which further travels along the pair of Y-axis members **703**. The extruder tool head **704** may connect the tubing to material deposit modules to output road repair material into the extrusion nozzle **705**. The tool head **704** may actuate asphalt extrusion through the nozzle **705** via a trigger, valve, or other mechanism. The extruder nozzle **705** is where the road repair material may be extruded from onto the road.

[0097] The extruder nozzle **705** may be connected to a deposit tubing **706**, which may connect to the trailer loaded custom extrusion mechanism. In various embodiments that comprises a direct drive extrusion system, no tubing may be required, and the extrusion mechanism will be on the extruder tool head. The motion controller may be located on a cutout **707** in the floor of the truck to allow extrusion into the road.

[0098] In various implementations, additional positional enhancement components may be configured on the motion controller **700** to improve tracking and synching of the gantry movement to the vehicle movement. The positional enhancement components may comprise optical sensors that ensure the movement speed and direction of the extruder head on the gantry match those of the vehicle. The speed of the extruder movement on the gantry may be changed in real time in response to any sudden movement change of the vehicle. In various implementations, the motion controller may be configured to accurately direct the gantry movement to correspond to the vehicle movement.

ASPECTS OF THE DISCLOSURE

[0099] The detailed description provided above in connection with the appended drawings explicitly describes and supports various features of a mobile road treatment system. By way of illustration and not limitation, supported aspects include a mobile road surface treatment system. The system comprises a control module on a vehicle, a scanner at front end of the vehicle, a preparatory apparatus installed on the vehicle proximately behind the scanner, a material handling apparatus, configured to contain and maintain road fill compound, installed on cargo bearing section of the vehicle, a plurality of cameras installed on perimeter of underside of the vehicle, a repair unit comprising a deposit module installed on a plurality of unit guide rails, wherein the unit guide rails are movably connected to one another, and a post repair module. The system is configured such that the vehicle is configured to travel at a moving speed and a moving direction. The control module is configured to receive input from the scanner, the plurality of cameras, and

the vehicle and generates an instruction to the preparatory apparatus, the material handling apparatus, and the repair unit. The instruction controls the preparatory apparatus to remove debris from a pothole. The instruction controls the repair unit to move on the plurality of unit guide rails in corresponding speed to the moving speed and corresponding direction to the moving direction. The instruction controls the material supply apparatus to supply the road fill compound to the deposit module. The deposit module deposits the road fill compound into the pothole, and the post repair module renders the road fill compound into a flat condition in the pothole.

[0100] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein control module is a cloud computing network.

[0101] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the repair unit comprises at least one alternative deposit module.

[0102] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the preparatory apparatus comprises an air blower.

[0103] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the post repair module comprises a roller.

[0104] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle. The method comprises driving the vehicle with a scanner, a plurality of cameras, a preparatory apparatus, a material handling apparatus, a repair unit, and a post repair module, to travel at a moving speed and a moving direction. The method further comprises transmitting input from the scanner, the plurality of cameras, and the vehicle, and then generate an instruction to the preparatory apparatus, the material handling apparatus, and the repair unit. The instruction is to instruct the preparatory apparatus to remove debris from a pothole, instruct the repair unit to move on a plurality of unit guide rails in corresponding speed to the moving speed and corresponding direction to the moving direction, and instruct the material supply apparatus to supply the road fill compound to the deposit module. Thereafter, the instruction commands to deposit the road fill compound into the pothole, and render the road fill compound into a flat condition in the pothole.

[0105] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, comprising a control module, a scanning module configured to detect a road cavity, and a material extrusion device mounted on a gantry on a vehicle configured to travel at a moving speed and moving direction. The system may be configured such that the control module instructs the material extrusion device to move on the gantry to hover above the road cavity and deposit repair material into the road cavity, corresponding to the moving speed and moving direction.

[0106] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the gantry comprises at least an X-axis and a Y-axis.

[0107] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system comprising a material preparation unit to maintain a consistency of the repair material, wherein the material extrusion device is connected to a material preparation unit on the vehicle.

[0108] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the control module is a server on a computing network connected to the vehicle.

[0109] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the scanning module comprises a computer vision model configured to generate a visualization the road cavity.

[0110] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the computer vision model communicates with the control module to implement isolation and conversion of the visualization of the road cavity.

[0111] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, comprising a road condition preparation module, configured to clean and remove debris from the road cavity.

[0112] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, comprising a material extrusion module connected to a material preparation unit on a gantry comprising at least an X-axis member and a Y-axis member, wherein the material extrusion module is configured to move along the X-axis member and Y-Axis member, a scanner module configured to detect a road cavity, and a control module on a vehicle having a moving speed and moving direction. The scanner module generates a geometric code for the road cavity, and the controller instructs the material extrusion module based on the geometric code to direct the material extrusion module to move along the X-axis member and Y-axis member and remain in a position above the road cavity. the material extrusion module deposits a repair material from the material preparation unit while the extrusion module hovers in the position.

[0113] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system wherein the control module is a server on a computing network connected to the vehicle.

[0114] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the scanning module comprises a computer vision model configured to generate a visualization the road cavity.

[0115] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the computer vision model communicates with the control module to implement isolation and conversion of the visualization of the road cavity.

[0116] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system comprising a road condition preparation module, configured to clean and remove debris from the road cavity.

[0117] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, comprising a tamping device configured to ensure the repair material is flush within the road cavity.

[0118] Supported aspects include any of the foregoing aspects and a mobile road surface treatment system, wherein the control module adjusts a deposit rate of the repair material based on the geometric code and the moving speed.

[0119] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle, comprising providing a vehicle with a scanner module, a control module, and a material extrusion module mounted on a gantry; driving the vehicle to travel at

a moving speed and a moving direction; detecting a road cavity with the scanner module and generating a geometric code; generating an instruction with the control module based on the geometric code, the moving speed, and the moving direction; directing, with the instruction, the material extrusion module to move along the gantry, such that the material extrusion remains in a position above the road cavity; and depositing a repair material through the material extrusion module while the extrusion module hovers in the position.

[0120] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle, comprising generating a visualization the road cavity.

[0121] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle, comprising implementing isolation and conversion of the visualization of the road cavity.

[0122] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle, comprising cleaning and removing debris from the road cavity.

[0123] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle, comprising tamping the repair material after deposit to ensure the repair material is flush within the road cavity.

[0124] Supported aspects include any of the foregoing aspects and a method for maintaining road surface on a moving vehicle, comprising adjusting a deposit rate of the repair material based on the geometric code and the moving speed.

[0125] The detailed description provided above in connection with the appended drawings is intended as a description of examples and is not intended to represent the only forms in which the present examples can be constructed or utilized.

[0126] It is to be understood that the configurations and/or approaches described herein are exemplary in nature, and that the described aspects, implementations and/or examples are not to be considered in a limiting sense, because numerous variations are possible.

[0127] The specific processes or methods described herein can represent one or more of any number of processing strategies. As such, various operations illustrated and/or described may be performed in the sequence illustrated and/or described, in other sequences, in parallel, or omitted. Likewise, the order of the above-described processes may be changed.

[0128] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are presented as example forms of implementing the claims.

What is claimed is:

1. A mobile road surface treatment system, comprising:

a control module,

a scanning module configured to detect a road cavity, and

a material extrusion device mounted on a gantry on a vehicle configured to travel at a moving speed and moving direction,

wherein

the control module instructs the material extrusion device to move on the gantry to hover above the road cavity and deposit repair material into the road cavity, corresponding to the moving speed and moving direction.

2. The mobile road surface treatment system of claim **1**, wherein the gantry comprises at least an X-axis and a Y-axis.

3. The mobile road surface treatment system of claim **1**, comprising a material preparation unit to maintain a consistency of the repair material, wherein the material extrusion device is connected to a material preparation unit on the vehicle.

4. The mobile road surface treatment system of claim **1**, wherein the control module is a server on a computing network connected to the vehicle.

5. The mobile road surface treatment system of claim **1**, wherein the scanning module comprises a computer vision model configured to generate a visualization the road cavity.

6. The mobile road surface treatment system of claim **5**, wherein the computer vision model communicates with the control module to implement isolation and conversion of the visualization of the road cavity.

7. The mobile road surface treatment system of claim **1**, comprising a road condition preparation module, configured to clean and remove debris from the road cavity.

8. A mobile road surface treatment system, comprising:

a material extrusion module connected to a material preparation unit on a gantry comprising at least an X-axis member and a Y-axis member, wherein the material extrusion module is configured to move along the X-axis member and Y-axis member,

a scanner module configured to detect a road cavity, and

a control module on a vehicle having a moving speed and moving direction

wherein

the scanner module generates a geometric code for the road cavity,

the controller instructs the material extrusion module based on the geometric code to direct the material extrusion module to move along the X-axis member and Y-axis member and remain in a position above the road cavity,

the material extrusion module deposits a repair material from the material preparation unit while the extrusion module hovers in the position.

9. The mobile road surface treatment system of claim **8**, wherein the control module is a server on a computing network connected to the vehicle.

10. The mobile road surface treatment system of claim **8**, wherein the scanning module comprises a computer vision model configured to generate a visualization the road cavity.

11. The mobile road surface treatment system of claim **10**, wherein the computer vision model communicates with the control module to implement isolation and conversion of the visualization of the road cavity.

12. The mobile road surface treatment system of claim **8**, comprising a road condition preparation module, configured to clean and remove debris from the road cavity.

13. The mobile road surface treatment system of claim **8**, comprising a tamping device configured to ensure the repair material is flush within the road cavity.

14. The mobile road surface treatment system of claim **8**, wherein the control module adjusts a deposit rate of the repair material based on the geometric code and the moving speed.

15. A method for maintaining road surface on a moving vehicle, comprising:

providing a vehicle with a scanner module, a control module, and a material extrusion module mounted on a gantry,

driving the vehicle to travel at a moving speed and a moving direction,

detecting a road cavity with the scanner module and generating a geometric code,

generating an instruction with the control module based on the geometric code, the moving speed, and the moving direction,

directing, with the instruction, the material extrusion module to move along the gantry, such that the material extrusion remains in a position above the road cavity,

and depositing a repair material through the material extrusion module while the extrusion module hovers in the position.

16. The method of claim **15**, comprising generating a visualization the road cavity.

17. The method of claim **15**, comprising implementing isolation and conversion of the visualization of the road cavity.

18. The method of claim **15**, comprising cleaning and removing debris from the road cavity.

19. The method of claim **15**, comprising tamping the repair material after deposit to ensure the repair material is flush within the road cavity.

20. The method of claim **15**, comprising adjusting a deposit rate of the repair material based on the geometric code and the moving speed.

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