United States Patent Application Publication · 20250254278
Kind Code · A1
Publication Date · August 07, 2025
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PROJECTION DEVICE FOR DISPLAYING CONSTRUCTION PLANS

Abstract

A projection device for displaying construction plans comprises a projector head having projection optics, a laser module, a first mirror galvanometer redirecting incident light from the laser module toward a second mirror galvanometer that redirects further the incident light toward the projection optics. A memory device stores one or more construction plans. A controller operatively connected to the laser module, the two mirror galvanometers, and the memory device chooses a construction plan to be displayed from the memory device, selectively activates the laser module, and selectively causes the first and second mirror galvanometers to follow a path defined by the chosen construction plan concurrently with the selective activation of the laser module so that the incident light redirected toward the projection optics selectively forms a projection of the construction plan on a construction site.

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Family ID: **70853560**

Appl. No.: **19/185652**

Filed: **April 22, 2025**

Related U.S. Application Data

parent US continuation 17298338 20210528 parent-grant-document US 12309535 WO continuation PCT/CA2019/051711 20191129 child US 19185652
us-provisional-application US 62772917 20181129

Publication Classification

Background/Summary

CROSS-REFERENCE [0001] The present application is a continuation of U.S. patent application Ser. No. 17/298,338, filed May 29, 2019, which is a National Stage Entry of International Application No. PCT/CA2019/051711, filed Nov. 29, 2019, which claims priority to U.S. Provisional Patent Application No. 62/772,917, filed on Nov. 29, 2018, the entirety of each of which is incorporated by reference herein.

TECHNICAL FIELD
[0002] The present disclosure relates to the field of projection devices. More specifically, the present disclosure relates to a projection device for displaying construction plans.
BACKGROUND
[0003] During construction and renovation, construction plans are made to describe the work to be done. Generally, the most used method to draw the layout of the construction plans on a construction site is to manually draw the construction plans on the surrounding areas with a tape measure with a chalk line or a pen.
[0004] This solution can be inaccurate and slow. Often, this work can also only be done by skilled workers. Both the time taken and the experience needed can increase costs of the construction job. Additionally, reality and construction plans have differences that may not be noticed until the layout has been drawn. In some cases, this could require the construction plans and/or the entire drawing work to be redone.
[0005] Some alternative solutions for presenting construction plans have been proposed. For example, in some solutions, a worker can produce a physical drawing as above, but aided by projection of points to represent specific reference points (a corner of a wall or other). The setup and installation of such solutions can be complex, however, and may be unsuited for unskilled workers or operators.
[0006] Therefore, there is a need for improvements for presenting construction plans that compensate for problems related to inaccuracies, wasted time and wasted efforts on construction sites.
SUMMARY
[0007] According to the present disclosure, there is provided a projection device for displaying construction plans. The projection device comprises a projector head, a memory device and a controller. The projector head comprises a set of projection optics, a laser module, and two mirror galvanometers, including a first mirror galvanometer configured to redirect incident light from the laser module toward a second mirror galvanometer, the second mirror galvanometer being configured to redirect the incident light from the first mirror galvanometer toward the set of projection optics. The memory device stores one or more construction plans. The controller is operatively connected to the laser module, the two mirror galvanometers, and the memory device. The controller chooses a construction plan to be displayed from the memory device, selectively activates the laser module, and selectively causes the first and second mirror galvanometers to

follow a path defined by the chosen construction plan concurrently with the selective activation of the laser module so that the incident light redirected toward the projection optics selectively forms a projection of the construction plan on a construction site.

[0008] According to the present disclosure, there is also provided a projection device for displaying construction plans. The projection device comprises a projector head, a memory device and a controller. The projector head comprises a set of projection optics, a laser module, a galvanometric system adapted to direct incident light from the laser module toward the set of projection optics, a yaw encoder adapted to detect in real-time a yaw of the projector head, and a pitch encoder adapted to detect in real-time a pitch of the projector head. The memory device stores one or more construction plans. The controller is operatively connected to the laser module, the galvanometric system, the yaw encoder, the pitch encoder, and the memory device. The controller chooses a construction plan to be displayed from the memory device, selectively activates the laser module, and selectively causes the galvanometric system to follow a path defined by the chosen construction plan concurrently with the selective activation of the laser module so that the incident light directed toward the projection optics selectively forms a projection of the construction plan on a construction site, the projection of the construction plan being adapted in real-time according to changes in the yaw, the pitch, or both the yaw and the pitch of the projector head.

[0009] The present disclosure further relates to a projection device for displaying construction plans. The projection device comprises a projector head, a memory device, a controller and a laser safety module. The projector head comprises a set of projection optics, a laser module, and a galvanometric system adapted to direct incident light from the laser module toward the set of projection optics. The memory device stores one or more construction plans. The controller is operatively connected to the laser module, the two mirror galvanometers, and the memory device. The controller chooses a construction plan to be displayed from the memory device, selectively activates the laser module, and selectively causes the first and second mirror galvanometers to follow a path defined by the chosen construction plan concurrently with the selective activation of the laser module so that the incident light redirected toward the projection optics selectively forms a projection of the construction plan on a construction site. The laser safety module is operatively connected to the laser module and is adapted for dynamically controlling an operation of the laser module.

[0010] According to the present disclosure, there is also provided a method of operation of the projection device. The projection device is positioned on a construction site. A construction plan is loaded in the projection device. The projection of the construction plan on the construction site is then initiated.

[0011] The foregoing and other features will become more apparent upon reading of the following non-restrictive description of illustrative embodiments thereof, given by way of example only with reference to the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Embodiments of the disclosure will be described by way of example only with reference to the accompanying drawings, in which:

[0013] FIG. **1** is a illustrative view of a projection device, shown in use, according to an embodiment of the present technology;

[0014] FIG. **2** is a front perspective view of the projection device of FIG. **1** according to an embodiment of the present technology;

[0015] FIG. **3** is an exploded, rear perspective view of the projection device of FIG. **1** according to an embodiment of the present technology;

[0016] FIG. **4** is an exploded view of a projector head of the projection device of FIG. **1** according to an embodiment of the present technology;

[0017] FIG. **5** is a schematic layout of components of the projection device of FIG. **1** according to an embodiment of the present technology;

[0018] FIG. **6** is a flow chart of a method of operating the projection device of FIG. **1** according to an embodiment of the present technology;

[0019] FIG. **7** is a flow chart of a method of operating the projection device of FIG. **1** according to another embodiment of the present technology;

[0020] FIG. **8** is a perspective view of a variant of a casing supporting a projector head according to another embodiment of the present technology;

[0021] FIG. **9** is perspective view of another variant of a casing supporting a projector head according to another embodiment of the present technology;

[0022] FIG. **10** is a block diagram of the projection device and its environment according to another embodiment of the present technology;

[0023] FIG. **11** is a flowchart showing operations of a dynamic laser projection according to an embodiment of the present technology;

[0024] FIG. **12** is a logical view of a hardware architecture of the projection device according to another embodiment of the present technology;

[0025] FIG. **13** is a side view of a laser projection size obtained using the projection device; and

[0026] FIG. **14** is a top view of the laser projection size obtained using the projection device.

[0027] Like numerals represent like features on the various drawings. It should be noted that the Figures are not necessarily drawn to scale.

DETAILED DESCRIPTION

[0028] Various aspects of the present disclosure generally address one or more of the problems related to inaccuracies, wasted time and wasted efforts on construction sites.

[0029] The present disclosure introduces a projection device that determines its position on a construction site with respect to known reference points on a construction site and, accordingly, project parts or all the whole of a building plan, a floor plan, a construction layout, and the like (generally referred to as a "construction plan"), depending on its spatial position (for example along an axis x and an axis y perpendicular to the axis x) and angular positions (i.e. orientation in terms of pitch and yaw) of a projector head. The reference points may be installed by an operator of the projection device on a local area where the projection device is put to use. It is contemplated that the reference points could be elements already present in the local area, for example marks placed on the floor by a professional surveyor or entities on the construction site, such as wall corners. Alternatively, an operator of the projection device or an assistant may install reference points on the construction site when setting up the projection device. Three or more reference points may be used to assist the positioning of the projection device. It is also contemplated that positioning information for the projection device on the construction site may be manually entered, the positioning information being defined by means external to the projection device.

[0030] The projection device is controlled either manually by hand by an operator, or by human machine interface (HMI) that is connected to the projection device by a wired or a wireless connection. The HMI may for example comprise a built-in interactive screen or an application running on a computer or any generic controller. The projection device is able to rotate 360 degrees on two axes including a vertical axis and a horizontal axis, and use laser projection to project pertinent information on surrounding surfaces, including floors, walls and ceilings. The projection device may be powered by use of one or more batteries and be capable of supporting a hot swap of the batteries to maintain an uninterrupted projection when changing a battery or Alternatively, the projection device may be powered through a cable connected into a wall outlet. Some embodiments of the projection device may be equipped with precise sensors adapted to detect movements brought to the projection device. The projection device may adapt its projection according to such

detected movements, therefore eliminating the need to recalibrate the projection each time the projection device is moved. The operator may use the HMI to modify the construction plan to be projected and add, delete or, move around image entities, for example walls, holes, doors, columns, and the like, if desired and depending on the embodiment. After the entities have been added, deleted, or moved, the projection device adapts the projection to reflect these changes. As such, the projection device allows the operator to reconcile differences between the construction plan and the reality of the construction site, adapting the construction plan as desired.

[0031] An embodiment of a projection device **100** according to the present technology will now be described with reference to FIGS. **1** to **3**. The projection device **100** receives construction plans from an external source and, based on these construction plans, defines guide lines that are projected onto surroundings on a construction site. The projected guide lines are instrumental in aiding construction workers in positioning various elements such as walls, doors, kitchen cupboard, and the like. The projection device **100** aids in reducing the workload and increasing the productivity of the construction workers by replacing the task of physically drawing out the construction plans' layout on the construction site. The workers are able to see any differences that may occur between reality and the construction plan before any actual construction work is done. Construction plan corrections may therefore be prepared and entered in the projection device **100** before any construction work is done and wasted. An operator of the projection device **100** and other construction workers may decide to draw on surfaces of the construction site, over the projection before starting work. Alternatively, the construction workers may decide to work directly over the laser projection. Some embodiments of the projection device **100** may be able to recognize and track objects moving on the construction site, automatically aim at reference points, measure distances between objects and/or between reference points, generate a three-dimensional (3D) virtual environment map that may be used for multiple purposes, for example to measure or evaluate flatness of surfaces using techniques described hereinbelow, or use the generated 3D virtual environment map as reference. Prism reflectors or custom-made targets having reflective surfaces may be disposed on the reference points to improve the accuracy of detection of the reference points. Features of the custom-made targets may support computer vision tracking features implemented in the projection device **100**.

[0032] The embodiment of the projection device **100** shown on FIGS. **2** and **3** includes a casing **110**. The casing **110** houses many components of the projection device **100**, including mechanical components, optical components, and computational components such as, without limitation, driver boards, microcontrollers, and terminals. The components disposed in the casing **110** will be described in more detail below. The casing **110** contains and protects components of the projection device **100**, also described in more detail below.

[0033] The projection device **100** includes a tripod **102** for supporting components of the projection device **100**. The casing **110** is selectively fastened to the tripod **102**. It is contemplated that the casing **110** could be supported by a different support structure. It is also contemplated that the casing **110** could be provided without any additional structure and could be placed on a surface in the area of operations.

[0034] The casing **110** receives a battery pack **120** to power the projection device **100**. The battery pack **120** includes a plurality of battery cells, but it is contemplated that different battery constructions could be used. It is also contemplated that the projection device **100** could be powered by different power sources than the battery pack **120**, for example by use of an electrical cord pluggable to a wall outlet.

[0035] The casing **110** also houses controller disposed therein. The controller may be implemented as a generic processor or as a group of generic processors, operatively connected to a memory device or to a group of memory devices and to one or more interfaces allowing the controller to communicate with other components of the casing **110**. In an embodiment, the controller is implemented as a System on Chip (SoC) **116**, for example a Jetson TX2 by NVidia or a NUC by

Intel. The SoC **116** is a computer device designed for and compressed to fit on a single board. The SoC **116** responsible for making most of the calculations and decisions for the projection device **100**. Without limitation, software running on the SoC **116** may have been written in C++ with an object-oriented architecture, or in JavaScript using a cross-platform runtime environment node.js. The SoC **116** is communicatively connected to and receives input from other components of the projection device **100** and delivers appropriate outputs. The calculations performed by the SoC **116** may comprise the translation of construction plans, entered by the operator, into angles of projection (described in more detail below). The SoC **116** may be equipped with a graphical processing unit (GPU), not separately illustrated, for 3D Processing and for interacting with a human machine interface (HMI) **190**. The SoC **116** may be operatively connected to a wireless communication hardware contained in the casing **110**. Through the wireless communication hardware, the projection device **100** may automatically update its firmware and download construction plans from secure remote servers. This also aids in monitoring of the projection device **100**, and it may help remote troubleshooting of any eventual hardware or software problems of the projection device **100**.

[0036] The HMI **190** allows a human operator to control the projection device **100**. In an embodiment, the HMI **190** may be a tablet running an iOS or an Android operating system and communicatively connected to the SoC **116** via wireless connection. It is contemplated that the HMI **190** could be connected to the SoC **116** via a hardwired connection in some embodiments. It is also contemplated that the HMI **190** could be of a different form, including but not limited to: an operator's personal phone, an application running from a computer, an interactive screen built into the projection device **100**, and a custom controller similar to a gamepad. It is further contemplated that the HMI **190** could be integrated in the projection device **100**, for example as a liquid crystal display (LCD) screen.

[0037] The casing **110** includes two ergonomically designed handles **122** fastened to the casing **110**. The handles **122** are provided for convenient carrying of the projection device **100**. It is contemplated that the handles **122** could be omitted in some embodiments.

[0038] The casing **110** also houses a projector head **150**. The casing **110** also houses a rotational motor **140** (see FIG. **4**). The motor **140** is operatively connected to the projector head **150** to control and determine a vertical angular position (pitch) of the projector head **150**.

[0039] With reference to FIG. **4**, components of the projector head **150** will now be described. The projector head **150** includes a housing **152** for housing the various components of the projector head **150**. Attached to the housing **152** is a mounting apparatus **154** that connects the projector head **150** to the motor **140**. The mounting apparatus **154** may be constructed of various different mechanical components.

[0040] The projector head **150** includes a rangefinder **158** to measure distances between the projection device **100** and a targeted area on the construction site. The rangefinder **158** may be used to determine the distances between the projection device **100** and the reference points. In an embodiment, the rangefinder **158** may comprise a laser-based rangefinder, although different types of rangefinders could be used in other embodiments. In an embodiment, the rangefinder has a precision of ±1 mm.

[0041] The projector head **150** also includes two cameras **172** to generate a 3D map of the environment, detect object, track moving objects, and measure environment luminance of surfaces such as floors, walls and ceilings on the construction site. The SoC **116** may control a power level of the laser module **160** as a function of the measurement luminance so that a brightness of a construction plan projected by the projection device **100** matches the environment luminance. As such, the power level of the laser module **160** may increase in the daytime and decrease during the evening or when the construction site is a generally dark environment. In an embodiment, stereo vision from the two cameras **172** may be used to determine the distances between the projection device **100** and the reference points. In the same or another embodiment, one camera **172** may be

used to track moving objects and the other camera may be used to generate the 3D map, and/or measure the luminance of surfaces.

[0042] Some embodiments of the projection device **100** are adapted to measure or evaluate flatness of surfaces such as floors, walls and ceilings on the construction site. In one embodiment, the two cameras **172** (and optionally additional cameras) capture images of the floor in a same location on the construction site and the SoC **116** implements a homography calculation based on these images to calculate the flatness and/or elevation of the floor. In another embodiment, the rangefinder **158** takes three or more distance measurements from the projector head **150** to a location on the floor of the construction site, taking notes of angular positions associated to these measurements. The SoC **116** calculates a mean elevation of the floor based on these measurements. In a further embodiment, a LIDAR sensor (not shown) is integrated in the projection device **100**. The LiDAR sensor scans the construction site to generate a 3D cloud of points representing the construction site, including the floor. The SoC **116** calculates the flatness and elevation of the floor based on the 3D cloud of points.

[0043] The projector head **150** also includes an optical system including a laser module **160**, a galvanometric system **164**, and a set of projection optics **166**. The laser module **160** may for example be a continuous solid-state laser, but it is contemplated that different laser systems could be implemented, including but not limited to pulsed lasers, HeNe lasers, and CO.sub.2 lasers. For example and without limitation, the laser module **160** may be a 40 mW laser emitting at a 532 nm wavelength.

[0044] The galvanometric system **164**, also referred to as a galvo **164**, is an electromechanical mechanism including two mirror galvanometers **174** having integrated actuators, for example 6220H devices from Cambridge Technology Inc. The galvanometric system **164** is communicatively connected to the SoC **116** to receive instructions therefrom. The galvanometric system **164** transmits a light beam generated by the laser module **160** and incident thereon to a desired target on the construction site by changing the angles of the mirrors relative to the incident beam angle. In place of the galvanometric metric system **164**, the projector head **150** could instead or additionally include acousto-optic, electro-optic scanners, resonant and polygonal scanner. Additionally, the galvanometric system **164** could include more than one set of galvanometers scanners.

[0045] The projection optics **166** of the shown embodiment include a lens **168** and an aperture **169**. More lenses and optical elements such as filters could be included with the projection optics **166**, depending on the specific embodiment. In some embodiments, the projector head **150** could omit lenses, depending on details of the embodiment.

[0046] The optical system operates generally as follows. The SoC **116** calculates vector sets representing various points of a construction plan loaded on the projection device **100**. Based on these vector sets, the SoC **116** causes the laser module **160** to selectively emit a collimated laser beam onto the galvanometric metric system **164**. Also based on these vector sets, the SoC **116** causes the galvanometric metric system **164** to selectively direct the laser beam to variable angles that are controlled according to instructions from the SoC **116**, based on the angles of projection defined in the vector sets and calculated on the basis of the construction plan. The thus directed laser beam is then transmitted through and projected by the optics **166**. The galvanometric metric system **164** rapidly sweeps the laser beam along the angles that correspond to a visualization to be produced on a surrounding environment for the construction plan. Embodiments of the projection device **100** are adapted to project construction plans up to 10 meters or more from the projection device, with a width of 10 meters or more. The same or other embodiments are capable of maintaining a ±3 mm accuracy of points on the projected construction plans, in an ideal environment when the projection is made on a flat surface. The accuracy of the points on the projected construction plans may be impacted by various irregularities on the construction site and/or by human error. Divergence of laser (edge to edge) is within 12 mm in most situations.

[0047] An overall schematic diagram of the projection device **100**, including some of both the mechanical components and computation components, is illustrated in FIG. **5**. It should be noted that this is just one non-limiting embodiment and less, additional and/or alternative components could be included in some cases. The embodiment of FIG. **5** shows the projection device **100** including the SoC **116**, the laser module **160** connected to the SoC **116** via a relay **180**, the rangefinder **158**, the cameras **172**, a remote controller, for example the HMI **190** being wirelessly connected to the SoC **116**, a galvo driver **182** for the galvanometric mirrors **174**, a memory device operatively connected to the SoC **116**, for example a flash memory **184**, the motor **140**, which may be a servo motor, the motor **140** being controlled by the SoC **116** to adjust the pitch axis of the projector head **150**. For example and without limitation, the galvo driver **182** may be a 673 Series servo driver from Cambridge Technology. A module including a driver **186** connected to a motor **187** (either a DC motor or a stepper motor) is operatively connected to the SoC **116** via analog signals. The encoder **188** provides real-time indications of a yaw axis of the projector head **150** and, in response, the SoC **116** controls the switching circuit **186** and the stepper motor **187** to adjust the yaw axis of the projector head **150**. If the pitch or the yaw of the projector head **150** changes over time, the SoC **116** may recalculate in real-time the vector sets to adjust the projection of the construction plan accordingly.

[0048] In an embodiment, the projection device **100**, specifically the SoC **116** and other computational systems therein, may perform a file conversion. Conventionally, most construction plans are drawn with popular commercial software products such as AutoCAD™, Revit™ or Tekla Structures™. The output file formats of these software products are in standard format such as ".dwg", ".rvt", ".dxf" or ".dwf" files. In this embodiment, the construction plans are first converted into a predetermined, proprietary format (referred to as .msys or .mec file formats in the present disclosure) that may communicate with the projection device **100**. This is mainly due to the fact that original construction plans files are full of information elements that are not useful for the operator and would muddle up the image being projected. Example of such information elements may include dimensions that appear on construction plans, their projection being less useful when the construction plan is projected in actual size on the construction site. For this reason, the file is "cleaned up", or simplified, to remove information elements that are considered unimportant by the operator, before its upload onto the projection device **100**. This "clean-up" may be automated in an embodiment. In particular, one feature of the projection device **100** may allow the operator to individually select components on the construction plans on a graphical user interface (GUI) of the HMI **190** and move them as the operator wishes, the projection device **100** modifying the projection of the construction plan accordingly. The conversion of the construction plan into the proprietary format facilitates the control over the file structure of the construction plan and thus facilitates changing the construction plan according to the desires of the operator. The conversion of the construction plan into the proprietary format facilitates its manipulation, allowing the operator of the projection device **100** to modify, for example translate, rotate, resize, add or delete elements of the construction plan. Calculations by the SoC **116** of the vector sets that represent the various points of the construction plan and are used to control the laser module **160** and the galvanometric system **164** are also facilitated by this conversion. Cybersecurity is also enhanced by this conversion to the proprietary format. Construction plans are usually trade secrets and properties of our customers. The conversion of the construction plans to the proprietary format by the projection device **100** is useful in preventing unauthorized extraction of the construction plans.

[0049] With reference to FIG. **6**, a method of operating the projection device **100** will now be described. On FIG. **6**, a sequence **200** comprises a plurality of operations, some of which may be executed in variable order, some of the operations possibly being executed concurrently, some of the operations being optional. The sequence **200** begins with setting up the projection device **100** on the construction site at operation **210**. The operator unloads components of the projection device **100** from a carrying case. The operator then assembles the projection device **100** by fastening the

casing **110** onto the tripod **102**. The operator may then level the projection device **100** manually by adjusting the tripod **102**. In some embodiments, the operator could also instruct the projection device **100** to automatically level itself via the HMI **190**. In these embodiments, encoders (example of which are shown in FIG. **12**) may be integrated in the projection device **100** and provide their measurements to the SoC **116**. The SoC **116** may use these measurements to command the motors **140** and **187** to adjust the pitch and the yaw of the projector head **150**.

[0050] The sequence **200** continues with choosing a desired construction plan, for example a floor plan, at operation **220**. The operator picks the floor plan to project upon through the HMI **190**. One or more floor plans have been uploaded onto a memory device of the projection device **100** prior to use, either through a USB key or wireless communication such as WiFi, 4G, etc.

[0051] The sequence **200** continues at operation **230** with measuring reference points present in the construction site. The operator may cause the projection device **100** to automatically find and measure the reference points to locate itself in space within the construction site, calculating its position and orientation. Alternatively, the operator may use the HMI **190** to manipulate the projection device **100** to locate itself within the construction site. In any case, the projection device **100** may forward the resulting position and orientation to the HMI **190** for display on the GUI.

[0052] In one embodiment, the projection device **100** may be operated in a fixed position and orientation. In another embodiment, the projection device **100** may be configured to change its orientation to successively project distinct parts of the construction plan on distinct areas of the construction site. The sequence **200** may thus continue with manually controlling an orientation of the projection device **100** at operation **242**, for example by using a joystick or a directional pad part of the HMI **190**. Alternatively, one or both of the cameras **172** may automatically track a changing position of a reference device worn by the operator at operation **244** and the projection device **100** may orient itself accordingly. For manual control of the projection device **100** at operation **242**, the operator may have the option to turn all windings off on the motor **140** (FIG. **4**) and before manipulating the projection device **100** to the desired orientation. It is contemplated that the device could have a scope aligned with its optical path (the optical path of the projection and of the rangefinder **158**) that the operator may use to precisely take measurements, much like a total station instrument used by surveyors. In an embodiment the operator select one of two available control modes. The operator may control the projection device **100** to remain in a fixed orientation until a command is received from the HMI **190**. The operator may alternatively configure the projection device **100** to continuously track the changing position of the reference object worn by the operator. In the latter case, as the angular position of the operator changes on the construction site, the projection device **100** adjusts its projection to match the part of the floor plan to be projected accordingly.

[0053] The sequence **200** continues with starting the projection at operation **250**. The projection device **100** having located itself on the construction site, it projects all or part of the chosen floor plan, depending on the spatial position and angular position of the projection device **100** on the construction site and depending on the plan to be projected. The operator may interact with the HMI **190** to start or stop projection by the projection device **100**. The operator is able to interact with and change the floor plan through the HMI **190**. In particular, the operator may translate, rotate, resize, add or delete entities. This may especially be useful when the construction plans and the as-built environment on the construction site differ from one another. The changes made to the floor plan may be saved into a new floor plan without affecting the original floor plan. In any case, the changes may immediately be reflected by the laser projection. The HMI **190** may also provide commands to increase or decrease a brightness of the laser projection. It should be noted, however, that commands to increase the brightness of the laser projection may be overridden by safety considerations. A laser safety module **196** (FIG. **10**) intended to prevent eye damage that could be caused by the laser projection in various circumstances may be provided in an embodiment. This laser safety module **196** may limit the brightness of the laser projection regardless of commands

from the HMI **190**. The laser safety module **196** is described in more details below.

[0054] With reference to FIG. **7**, a method of operation of the projection device **100** will now be described. On FIG. **7**, a sequence **300** comprises a plurality of operations, some of which may be executed in variable order, some of the operations possibly being executed concurrently, some of the operations being optional. The sequence **300** begins with automatic or manual calibration of the motor **140** and leveling of the projection device **100** at operation **310**. Leveling of the projection device **100** may comprise adjusting one or both of the pitch and the yaw of the projector **150**, for example according to the particularities of the construction site and according to the task at hand. It may be noted that, in this context, the term "leveling" does not necessarily imply placing the projector head **150** in a horizontal orientation. The calibration protocol may be initiated by the operator through the GUI on the HMI **190**. According to the calibration protocol, the projection device **100** follows a set of instruction to ensure all its components are correctly calibrated. This may include, without limitation, the use of stepper motors, of a set of cameras, of a rangefinder and of a leveling tool.

[0055] The sequence **300** continues with detecting reference points on the construction site at operation **320**, and taking distance measurements of the projection device **100** from the reference points at operation **330**. The sequence **300** then continues with determining coordinates of the projection device **100** at operation **340**.

[0056] The operator may use the GUI on the HMI **190** to cause the projection device **100** to automatically locate itself on the construction site. Alternatively, the positioning process of the projection device **100** may be performed manually. When done automatically, the projection device **100** searches known reference points present on the construction site with the help of computer vision or other technologies. The projection device **100** uses the rangefinder **158** to measure its distance to the reference points in view of determining its position relatively to those points, using for example trilateration or other mathematical calculations.

[0057] The projection device **100** may integrate other technologies to measure its distance to the reference points. For example, an embodiment of the projection device **100** may use a 3D cloud of points generated by the above-mentioned LIDAR sensor. In this embodiment, the LiDAR sweeps an area of the construction site to generate the 3D cloud of points. The SoC **116** manipulates and transforms the content of the 3D cloud of points to generate an outline of the construction site. The outline is then transformed by the SoC **116** into vectors and coordinates that are compared mathematically with the construction plan to determine the position of the projection device **100**. This embodiment may further use information entered on the HMI **190** by the operator pointing on an area of the construction plan to define on a broad level the position of the projection device.

[0058] The sequence **300** may then continue with determining if the construction drawings file is in the proper format at operation **350**. In an embodiment, before projecting the construction plans, the projection device **100** may read the file format and determine whether it is in the proprietary format (such as a .mec or .msys file). In this embodiment, the projection device **100** may display an error message on the GUI on the HMI **190** at operation **355**, if the file is not in the proprietary format. It is contemplated that the sequence **300** may terminate after operation **355**. It is also contemplated that, alternatively, the sequence **300** may continue at operation **360**, after operation **355**. It is further contemplated that operations **350** and **355** may be omitted in an embodiment.

[0059] The sequence **300** then continues at operation **360** with adapting a projection of the construction site by determining a projection zone and projecting the construction plan in the determined projection zone at operation **370**. Depending on the position and orientation of the projection device **100**, the complete construction plan or a part thereof may be projected. In the course of operations **360** and **370**, the projection device **100** may stay in a fixed orientation and continuously project the construction plans in its initial orientation. The projector head **150** may be moved while the construction plan is being projected. These movements may be performed manually by the operator or through commands from the HMI **190** to alter the pitch and/or the yaw

of the projector head **150**. A pitch encoder **406** and a yaw encoder **410** (FIG. **8**) may provide real-time measurements of the orientation of the projector head **150** to the SoC **116**. Alternatively or in addition, the projection device **100** may continuously track and follow the changing position of the reference device worn by the operator (in some cases, a site foreman) and modify the orientation of the projector head **150** accordingly. Stereo vision from the two cameras **172** or other tracking techniques may detect the movements of the reference device worn by the operator. In any case, the projection device **100** may dynamically and in real-time adjust the projection according to the construction plan, the construction site, and the changing orientation of the projector head **150**. In an embodiment, the projection device **100** may refrain from adjusting the projection for small movements of the reference device or for small movements of the projection device.

[0060] Various embodiments of the projection device for displaying construction plans and of its operating methods, as disclosed herein, may be envisioned. Such embodiment may comprise variants of the projection device having a casing **400** shown on FIG. **8** or a casing **500** shown on FIG. **9**.

[0061] As shown on FIG. **8**, the casing **400** supports the laser module **160**. A leveling system supporting the laser module **160** comprises a pitch encoder **406**, a pitch motor **408**, a yaw encoder **410**, and a yaw motor **412**. A pitch of the projector head **150** may be adjusted under control of the SoC **116** receiving real-time signals from the pitch encoder **406** and providing control signals to the pitch motor **408**. A yaw of the projector head **150** may be adjusted under control of the SoC **116** receiving real-time signals from the yaw encoder **410** and providing control signals to the yaw motor **412**. Without limitation, the pitch motor **408** and the yaw motor **412** may be stepper motors. As the pitch and the yaw of the projector head **150** are adjusted, the light directed by the mirror galvanometers **174** is directed toward a selected zone within the construction area. In an embodiment, the pitch and the yaw of the projector head **150** may be continuously adjusted. The cameras **172** and the rangefinder **158** are mounted on a camera module **414** that is itself mounted on the laser module **160** so that the cameras **172** and the rangefinder **158** directly track the orientation of the mirror galvanometers **174**. The cameras **172** may be able to track the reference device at a distance of 50 meters or more. The cameras **172** may include motorized lenses for automatic focus on long distance targets, for example up to 150 meters away. In an embodiment, the projection device **100** may redirect images captured by the cameras **172** for display on the HMI **190**.

[0062] A shown on FIG. **9**, the casing **500** is another variant that supports similar components as those introduced earlier in the present disclosure. The casing **500** comprises a support **502** mounted on the laser module **160** and supporting the rangefinder **158** and the cameras **172**. The casing **500** also supports a laser alignment apparatus **504** controlled by the SoC **116** and operative to adjust at least a pitch of the laser module **160** and of the support **502**.

[0063] FIG. **10** is a block diagram of the projection device and its environment according to another embodiment of the present technology. In the shown embodiment, the SoC **116** is a central part of the projection device **100**. It is connected to the HMI **190**, for example via wireless communication using a WiFi, 4G or 5G protocol, to peripherals **192** via a serial communication protocol, to a database **194** and to the laser safety module **196**.

[0064] The peripherals **192** may include the motors **140** and **187**, the laser module **160**, the galvanometric mirrors **174**, the rangefinder **158** and the cameras **172**.

[0065] SoC **192** may use a structured query language (SQL) protocol to obtain construction plans from the database **194**, to verify customer accounts stored in the database **194**, and to cause the database **194** to store logs of changes brought to the construction plans while using the projection device **100**.

[0066] The HMI **190** may be connected to a user interface applications entity **198** that defines parameters for the display of construction plans, interactions of the operator with the displayed construction plans, and generally for control of the projection device **100**.

[0067] FIG. **11** is a flowchart showing operations of a dynamic laser projection according to an embodiment of the present technology. On FIG. **11**, a sequence **700** comprises a plurality of operations, some of which may be executed in variable order, some of the operations possibly being executed concurrently, some of the operations being optional. The sequence **700** begins with loading of a construction plan of interest on the projection device **100** at operation **710**. The construction plan, which may be in a proprietary format (.msys or .mec), is queried from database **194** and stored in the memory device of the projection device **100**.

[0068] Spatial positioning information of the projection device **100** is determined at operation **720**. This operation **720** allows determining relative locations of three (or more) reference points and of the projection device **100** on the construction site based on measurements of distances between the projection device **100** and the reference points. In an embodiment, trilateration is used in operation **720**. In more details, distance measurements are taken by the rangefinder **158** for three or more reference points. For each distance measurement, an angular position is read from the pitch axis encoder **406**. The measured distances are mathematically projected to ground level to determine two-dimensional (2D) distances between the projection device **100** and the reference points. The three (or more) 2D distance values are used to calculate a position of the projection device **100** along two horizontal axes (X, Y). The position of the projection device **100** may further be evaluated along a third vertical axis (Z) if one or more of the reference points is not on ground level. It is contemplated that, instead of trilateration based on distance measurements taken by the rangefinder **158**, the 3D cloud of points generated by the LiDAR may be used by the SoC **116** to determine the spatial positioning of the projection device **100**.

[0069] A potential keystone effect may be compensated at operation **730**. To this end, current pitch and yaw angular positions of the projector head **150** may be read in real-time from the pitch axis encoder **406** and from the yaw axis encoder **410** by the SoC **116**. The SoC **116** may then use the pitch and yaw angular positions of the projector head **150** to generate equivalent vector sets that are modified from the vector sets originally calculated based on the construction plan. The equivalent vector sets are used to compensate the projection of the construction plan for the potential keystone effect.

[0070] Operation **740** may comprise a selection of a part of the construction plan to be displayed on a projection zone of the construction site. Boundaries of a field of view of the projection device **100** are evaluated by the SoC **116** based at least in part on the position of the reference points to define a projection zone. The SoC **116** determines lines of the construction plan that intersect with these boundaries. The construction plan is clipped by removing elements of the construction plan that would be positioned outside of the projection zone. The SoC **116** then controls the laser module **160** and the mirror galvanometers **174** to display unclipped parts of the construction plan within the projection zone. It is understood that, in some situations, the complete construction plan may be displayed at once, particularly when the construction plan does not contain elements beyond the field of view of the projection device.

[0071] Projection of the construction plan on the construction site on the construction site, or projection of a part of the construction plan when the construction plan is clipped to fit within the field of view of the projection device **100**, is started at operation **750**. The SoC **116** concurrently generates control signals defined based on the vector sets and communicated to the galvo driver **182** for the galvanometric mirrors **174** and other control signals communicated to the laser module **160**. These control signals may be converted from a digital format emitted by the SoC **116** to an analog format, as will be shown in the description of FIG. **12**. In an embodiment, the SoC **116** may recalculate vector sets and generate hundreds of such signals for each degree of rotation of the mirror galvanometers **174**.

[0072] The projection device **100** may optionally be used on a construction site where no reference point is available. In an embodiment, positioning information for the projection device **100** may be manually entered by the operator using the HMI **190**. Alternatively, if the position of the projection

device **100** cannot be obtained, the operator may cause the projection device to execute at least operations **720** and **750** so that the construction plan is projected on the construction site, this projection being quite inaccurate in most circumstances. The operator may then move the projection device **100** to illuminate a desired area of the construction site, use the HMI **190** to select a part of the construction plan that matches the area of the construction site that is illuminated by the projection device **100**, translate, rotate and/or scale the projected image to fit with the projection area, adjust a focus of the projection. Once these adjustments are made to the satisfaction of the operator, the HMI **190** may provide to the projection device **100** a command to store the current settings in the memory device.

[0073] FIG. **12** is a logical view of a hardware architecture of the projection device according to another embodiment of the present technology. In this embodiment, the SoC **116** is complemented by another microcontroller **420**, for example and without limitation an Arduino Due, and by a specialized controller card **430**, for example and without limitation a ScanMaster controller from Cambridge Technology. The microcontroller **420** and the specialized controller card **430** are mainly used to offload some processing from the SoC **116** and may be omitted in some implementations.

[0074] The microcontroller **420** acts as an interface for exchanging in real-time digital signals between the SoC **116** and the pitch axis encoder **406**, a stepper motor driver **422** controlling the pitch axis motor **408**, the yaw axis encoder **410** and a stepper motor driver **424** controlling the yaw axis motor **412**. The specialized controller card **430** is connected to a TCP/IP socket of the SoC **116** and translates control signals of the SoC **116** for the laser module **160** into analog control signals applied to the laser module **160**. The specialized controller card **430** also forwards digital control signals of the SoC **116** intended to control the mirror galvanometers **174** to a high precision digital to analog convertor (DAC) **432**, for example a 16-bit DAC. The DAC **432** translates these control signals into analog signals having an equivalent 16-bit precision. The analog signals are applied to the galvo driver **182** that actuates the mirror galvanometers **174**. In an embodiment, the shown galvo driver **182** may be substituted with another galvo driver capable of receiving control signals in digital format, for example a XY 2-100 from Newson Engineering. The DAC **432** may be omitted in this embodiment.

[0075] A communication module **440** embedded in the projection device **100** and communicatively coupled to the SoC **116** allows the SoC **116** to communicate wirelessly, using a 4G or a 5G connection, with an external database **442** implemented on a web site. The SoC **116** may query the database **442** to obtain software upgrades for operation of the projection device **100**, access construction plans and client accounts, and the like. Communication of the SoC **116** with the HMI **190** may take place over a WiFi connection, using a REST application programming interface (API). Use of other communication protocols, for example Bluetooth, or use of wired connections, is also contemplated.

[0076] The laser safety module **196** may be provided for the eye safety of the personnel on the construction site. The laser safety module **196** is connected to and is adapted to dynamically control operations of the laser module **160**. For example, the laser safety module **196** may interrupt the laser module **160** when the presence of a person near the projection device **100** is detected or when a fault is detected in the projection device **100**. The laser safety module **196** may also dynamically attenuate an intensity of the laser module **160** to maintain a brightness of the projected construction plan within a safe level.

[0077] In more details, the laser safety module **196** includes a real-time monitoring function of a signal provided by a proximity detector when detecting persons located in the optical path of the projection device **100** and at a close distance from the projection device **100**. The laser safety module **196** implements an emergency laser shutdown function that interrupts the operation of the laser module **160** when the signal from the proximity detector is interpreted as a safety hazard for that person. One of the cameras **172** may act as the proximity detector and provide images that are used to detect the presence of a person near the projection device **100**. In an embodiment, the laser

safety module **196** may be directly connected to the laser module **160** so that laser emission may be interrupted rapidly, without the need for intervention by the SoC **116**. In an embodiment, the signal from the proximity detector may indicate a distance between the person and the projection device **100** and the laser safety module **196** may consider a power level of the laser module **160** and the distance between the person and the projection device **100** to determine whether there is a safety hazard for that person. Control of the laser module **160** when the proximity detector detects the presence of a person close to the projection device **100** but outside of the optical path of the projection device **100**, for example when a person is standing behind the projection device **100**, is also contemplated.

[0078] The laser safety module **196** may also receive a fault indication from various components of the projection device. As an example, the fault indication may be received from the galvo driver **182** when the mirror galvanometers **174** have stopped their normal operation, causing the projection device **100** to direct the laser beam to a single point according to a fixed position of the mirror galvanometers. Other fault indications may be received from the SoC **116** and relate, for example, to a breakage of the casing **110** or of the projection optics **166** that may cause the laser beam to leak in various directions. Another example of a fault indication may relate to a software fault in the SoC **116** or to a communication error between the SoC **116** and other components of the projection device **100**. The laser safety module **196** may interrupt the operation of the laser module **160** in response to any fault indication

[0079] The laser safety module **196** is configured to evaluate a risk of eye damage caused by the light emitted by the projection device **100** to any person on the construction site. This risk is evaluated in view of a brightness of the projection of the construction plan and in view of a safety threshold based on scientific data related to safe levels of retinal exposure to laser light sources. The brightness of the projection of the construction plan is calculated based on a power intensity (in mW) of the laser module **160**, in view of a size of the aperture **169**, in view of a type of the laser including its wavelength. The laser safety module **196** may further estimate the brightness of the projection on the construction site by considering one or more of a number of lines on the projection of the construction plan, a length of the lines, a combined length of the lines, intersections between the lines, an environmental luminosity, and a number of jumps in the projection of the construction plan. These parameters allow the laser safety module **196** to evaluate a brightness of the laser projection in any given section of the projected construction plan. Information about a maximum power level and other characteristics of the laser module **160** may be stored in the memory device connected to the SoC **116**. Storing in the memory device a reference table based on the scientific data related to safe levels of retinal exposure to laser light sources is also contemplated. This information stored in the memory device may be preloaded in the laser safety module **196** when the projection device **100** is initially powered on. The laser safety module **196** dynamically controls the laser module **160** by attenuating its intensity until the brightness of the projection of the construction plan is less than the safe level of retinal exposure. In an embodiment, the laser safety module **196** controls the brightness of each line on the projection of the construction plan to dynamically maintain a brightness density of the projection in any given section of the projected construction plan below the safe level of retinal exposure.

[0080] Referring again to FIG. **10**, a feedback loop may be implemented between the laser safety module, the SoC **116**, and peripherals **192** containing the laser module **160** so that the emitted intensity of the laser beam is maintained at a safe level in any region of the projected construction plan.

[0081] Embodiments of the projection device **100** are made to be compliant with relevant standards and operation criteria. In particular, the projection device **100** is adapted to withstand environmental hazards of the construction site, including accidental impacts, occasional rain, prolonged used in hot or freezing temperatures, and prolonged exposition to the sun. For example, the projection device **100** may be impact resistant, waterproof, dustproof and/or water resistant. In

particular, the projection device **100** may comply with the IP **55** specification of the National Electrical Manufacturers Association (NEMA) and/or meet the IK08 rating defined in the European standard EN 62262. The projection device **100** may further comply with various Design for Manufacturing and Assembly (DFMA) guidelines.

[0082] FIGS. **13** and **14** respectively show a side view and a top view of a laser projection size obtained using the projection device **100**. Numerical values shown on FIGS. **13** and **14** are typical and do not limit the present disclosure. Dimensions are in mm, except for angles that are in degrees.

[0083] In a typical use case, the projection device **100** is mounted on its tripod **102** and stands at 1700 mm above floor level, this height and the position of the projection device **100** on the floor defining an original of projection reference point. A pitch angle of the projector head **150** is set to 29 degrees below horizontal because it is desired to project the construction plan on the floor. The mirror galvanometers **174** have 80 degrees of optical range both in the horizontal and in the vertical direction. On FIG. **14**, this range is split into 40 degrees left and right of a direct line from the projection device **100** and defines a projection zone. Given the pitch angle of the projector head **150**, a maximum depth of the projection zone is about 23.8 meters and a width of the projection zone at the maximum depth is about 18.5 meters on each side of the direct lien from the projection device **100**. On FIG. **13**, a laser dot emitted by the projection device **100** when the mirror galvanometers **174** are both in their center position is placed at about 2.43 meters from the projection device **100**. When the mirror galvanometers **174** are oriented at their lowest angle, 40 degrees below the pitch angle of the projector head **150**, the laser light comes as close as 691 mm from the projection device **100**. A dead zone having a depth of 691 mm is thus defined from the position of the projection device **100**. Although the mirror galvanometers **174** can be oriented at 40 degrees above the pitch angle of the projector head **150**, excessively raising the angle of the mirror galvanometers **174** would lead to the projection device **100** emitting its laser beam horizontally, to an infinite distance. In practice, the mirror galvanometers **174** may be controller to rise up to 25 degrees above center, the aim of the laser beam being at 4 degrees below horizontal when factoring the pitch angle of the projector head **150**. Rising up the mirror galvanometers **174** to 25 degrees allows the laser beam to reach a point on the floor at about 23.8 meters (as shown on FIG. **14**).

[0084] Although the projection device **100** may be able to project construction plans over the projection zone illustrated as a triangle on FIG. **14**, the projection device **100** may be operated to limit the projection zone to a smaller size within which accuracy of the projection is more easily controlled.

[0085] Those of ordinary skill in the art will realize that the description of the projection device for displaying construction plans and of its operating methods are illustrative only and are not intended to be in any way limiting. Other embodiments will readily suggest themselves to such persons with ordinary skill in the art having the benefit of the present disclosure. Furthermore, the disclosed projection device and operating method may be customized to offer valuable solutions to existing needs and problems related to inaccuracies, wasted time and wasted efforts on construction sites. In the interest of clarity, not all of the routine features of the implementations of the projection device and operating method are shown and described. In particular, combinations of features are not limited to those presented in the foregoing description as combinations of elements listed in the appended claims form an integral part of the present disclosure. It will, of course, be appreciated that in the development of any such actual implementation of the projection device and operating method, numerous implementation-specific decisions may need to be made in order to achieve the developer's specific goals, such as compliance with application-related, system-related, network-related, and business-related constraints, and that these specific goals will vary from one implementation to another and from one developer to another. Moreover, it will be appreciated that a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking of engineering for those of ordinary skill in the field of projection devices having the

benefit of the present disclosure.

[0086] In accordance with the present disclosure, the components, process operations, and/or data structures described herein may be implemented using various types of operating systems, computing platforms, network devices, computer programs, and/or general purpose machines. In addition, those of ordinary skill in the art will recognize that devices of a less general purpose nature, such as hardwired devices, field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), or the like, may also be used. Where a method comprising a series of operations is implemented by a computer, a processor operatively connected to a memory device, or a machine, those operations may be stored as a series of instructions readable by the machine, processor or computer, and may be stored on a non-transitory, tangible medium.

[0087] Systems and modules described herein may comprise software, firmware, hardware, or any combination(s) of software, firmware, or hardware suitable for the purposes described herein. Software and other modules may be executed by a processor and reside on a memory device of servers, workstations, personal computers, computerized tablets, personal digital assistants (PDA), and other devices suitable for the purposes described herein. Software and other modules may be accessible via local memory device, via a network, via a browser or other application or via other means suitable for the purposes described herein. Data structures described herein may comprise computer files, variables, programming arrays, programming structures, or any electronic information storage schemes or methods, or any combinations thereof, suitable for the purposes described herein.

[0088] The present disclosure has been described in the foregoing specification by means of non-restrictive illustrative embodiments provided as examples. These illustrative embodiments may be modified at will. The scope of the claims should not be limited by the embodiments set forth in the examples but should be given the broadest interpretation consistent with the description as a whole.

Claims

1. A projection device for displaying a construction plan, the projection device comprising: a projector head comprising: a set of projection optics, a laser module, and two mirror galvanometers, including a first mirror galvanometer configured to redirect incident light from the laser module toward a second mirror galvanometer, the second mirror galvanometer being configured to redirect the incident light from the first mirror galvanometer toward the set of projection optics; a memory device adapted for storing one or more construction plans; and a controller operatively connected to the laser module, the two mirror galvanometers, and the memory device, the controller being adapted for: choosing a construction plan to be displayed from the memory device, selectively activating the laser module, and selectively causing the first and second mirror galvanometers to follow a path defined by the construction plan concurrently with the selective activation of the laser module so that the incident light redirected toward the projection optics selectively forms a projection of the construction plan on a construction site.

2. The projection device of claim 1, further comprising a support structure, the projector head being selectively connected to the support structure.

3. The projection device of claim 1, further comprising: a rangefinder operatively connected to the controller and adapted to measure distances between the projection device and reference points positioned on the construction site; wherein the memory device is further adapted for storing known positions of reference points on the construction site; wherein the controller is further configured to: receive the measured distances between the projection device and the reference points, and calculating a position and an orientation of the projection device within the construction site based on the known positions of the reference points and on the measured distances between the projection device and the reference points.

4. The projection device of claim 3, wherein the controller is further configured to adapt the

projection of the chosen construction plan to a projection zone determined in view of the position and of the orientation of the projection device within the construction site.

5. The projection device of claim 4, further comprising: a first camera operatively connected to the controller and adapted to track a changing position of a moving reference point; wherein the controller is further configured to adapt the projection of the chosen construction plan in view of the changing position of the moving reference point.

6. The projection device of any one of claims 1 to 5, further comprising: a second camera operatively connected to the controller; wherein the controller is further configured to: detect a luminance of the construction site based on images provided by the camera; and adjust a power level of the laser module according to the luminance of the construction site.

7. The projection device of claim 1, further comprising: two or more cameras operatively connected to the controller and adapted to capture images of a floor of the construction site; wherein the controller is further configured to calculate at least one of a flatness and an elevation of the floor of the construction site based on the images of the floor provided by the two or more cameras.

8. The projection device of claim 1, wherein the controller is a system on chip.

9. The projection device of claim 1, further comprising: a leveling system supporting the projector head; wherein the controller is further configured to cause the leveling system to modify a pitch axis or a yaw axis or both the pitch and yaw axes of the projector head.

10. The projection device of claim 9, wherein: the leveling system comprises: a pitch encoder adapted to measure a pitch of the projector head, a pitch motor adapted to adjust the pitch of the projector head, a yaw encoder adapted to measure a yaw of the projector head, and a yaw motor adapted to adjust the yaw of the projector head; and the controller is further configured to receive measurements from the pitch encoder and from the yaw encoder to control the pitch motor and the yaw motor, respectively.

11. The projection device of claim 10, wherein the controller is further configured to adapt the projection of the chosen construction plan in view of a change of the pitch or the yaw or both the pitch and the yaw of the projector head.

12. The projection device of claim 1, further comprising: a pitch encoder adapted to measure a pitch of the projector head; a yaw encoder adapted to measure a yaw of the projector head; and wherein the controller is further configured to adapt the projection of the chosen construction plan in view of a change of the pitch, the yaw or both the pitch and the yaw of the projector head.

13. The projection device of claim 1, further comprising: a human machine interface (HMI) communicatively connected to the controller, the HMI being configured to forward to the projection device one or more commands selected from: a command to cause a calibration of the projection device, a command to control an orientation of the projection device, a command to cause a self-leveling of the projector head, a command to initiate a search for reference points positioned on the construction site a command to select the construction plan, a command to start the projection of the construction plan on the construction site, a command to increase a brightness of the projection, a command to decrease the brightness of the projection, a command to stop the projection of the construction plan on the construction site, and a command to modify the chosen construction plan.

14. The projection device of claim 13, wherein the HMI is communicatively connected to the controller via wireless connection.

15. The projection device of claim 13, wherein the HMI is communicatively connected to the controller via wired connection.

16. The projection device of claim 13, wherein the HMI is integrated in the projection device.

17. The projection device of claim 13, wherein the controller is further configured to: verify a format of the chosen construction plan; and cause the HMI to display a warning message if the chosen construction plan is not according to a predetermined format.

18. The projection device of claim 1, wherein the controller is further configured to: verify a format of the chosen construction plan; and prevent the projection of the construction plan on the construction site if the chosen construction plan is not according to a predetermined format

19. The projection device of claim 3, further comprising a human machine interface (HMI) communicatively connected to the controller, the HMI being configured to receive, from the controller, the calculated position and orientation of the projection device within the construction site and to display the calculated position and orientation of the projection device within the construction site.

20. The projection device of claim 1, further comprising a laser safety module operatively connected to the laser module, the laser safety module being configured to dynamically control an operation of the laser module.

21. The projection device of claim 20, wherein the laser safety module is adapted to receive a fault indication from a component of the projection device and cause an interruption of the laser module in response to the fault indication.

22. The projection device of claim 21, wherein the fault indication relates to a fault of one or both of the mirror galvanometers.

23. The projection device of claim 21, wherein the fault indication relates to a breakage of the projection optics or a breakage of a casing containing the projector head.

24. The projection device of claim 21, wherein the fault indication relates to a software fault of a communication fault reported by the controller.

25. The projection device of claim 20, further comprising a proximity sensor operatively connected to the laser safety module, the laser safety module being configured to: receive, from the proximity sensor, a signal indicating a presence of a person in close proximity to the projection device, and cause an interruption of the laser module when the laser safety module interprets the signal indicating the presence of the person in close proximity to the projection device as a safety hazard for that person.

26. The projection device of claim 25, wherein: the signal indicating the presence of the person in close proximity to the projection device includes a distance between the person and the projection device; and the laser safety module considers a power level of the laser module and the distance between the person and the projection device to determine whether there is a safety hazard for that person.

27. The projection device of claim 20, wherein the control of the operation of the laser module comprises dynamically attenuating an intensity of the laser module.

28. The projection device of claim 20, wherein the laser safety module is further adapted to: calculate a safe level of retinal exposure to laser light, estimate a brightness of the projection of the construction plan, and dynamically control the operation of the laser module by attenuating its intensity until the brightness of the projection of the construction plan is less than the safe level of retinal exposure.

29. The projection device of claim 28, wherein the laser safety module estimates the brightness of the projection of the construction plan by considering one or more of a number of lines on the projection of the construction plan, a length of the lines, a combined length of the lines, intersections between the lines, an environmental luminosity at the construction site, and a number of jumps in the projection of the construction plan.

30. The projection device of claim 29, wherein the laser safety module controls the brightness of each line on the projection of the construction plan to dynamically maintain a brightness density of the projection in any given section of the projected construction plan below the safe level of retinal exposure.

31. A projection device for displaying a construction plan, the projection device comprising: a projector head comprising: a set of projection optics, a laser module, a galvanometric system adapted to direct incident light from the laser module toward the set of projection optics, a yaw

encoder adapted to detect in real-time a yaw of the projector head, and a pitch encoder adapted to detect in real-time a pitch of the projector head; a memory device adapted for storing one or more construction plans; and a controller operatively connected to the laser module, the galvanometric system, the yaw encoder, the pitch encoder, and the memory device, the controller being adapted for: choosing a construction plan to be displayed from the memory device, selectively activating the laser module, and selectively causing the galvanometric system to follow a path defined by the chosen construction plan concurrently with the selective activation of the laser module so that the incident light directed toward the projection optics selectively forms a projection of the construction plan on a construction site, the projection of the construction plan being adapted in real-time according to changes in the yaw, the pitch, or both the yaw and the pitch of the projector head.

32. The projection device of claim 31, further comprising: a rangefinder operatively connected to the controller and adapted to measure distances between the projection device and reference points positioned on the construction site; wherein the memory device is further adapted for storing known positions of reference points on the construction site; wherein the controller is further configured to: receive the measured distances between the projection device and the reference points, calculating a position and an orientation of the projection device within the construction site based on the known positions of the reference points and on the measured distances between the projection device and the reference points, and adapt the projection of the chosen construction plan to a projection zone determined in view of the position and of the orientation of the projection device within the construction site.

33. The projection device of claim 32, further comprising: a camera operatively connected to the controller and adapted to track a changing position of a moving reference point; wherein the controller is further configured to adapt the projection of the chosen construction plan in view of the changing position of the moving reference point.

34. A projection device for displaying construction plans, the projection device comprising: a projector head comprising: a set of projection optics, a laser module, and a galvanometric system adapted to direct incident light from the laser module toward the set of projection optics; a memory device adapted for storing one or more construction plans; a controller operatively connected to the laser module, the galvanometric system, and the memory device, the controller being adapted for: choosing a construction plan to be displayed from the memory device, selectively activating the laser module, and selectively causing the galvanometric system to follow a path defined by the chosen construction plan concurrently with the selective activation of the laser module so that the incident light redirected toward the projection optics selectively forms a projection of the construction plan on a construction site; and a laser safety module operatively connected to the laser module, the laser safety module being adapted for dynamically controlling an operation of the laser module.

35. The projection device of claim 34, wherein the laser safety module is adapted to control a brightness of each line on the projection of the construction plan of the construction site to dynamically maintain a brightness density of the projection in any given section of the projected construction plan below a safe level of retinal exposure.

36. The projection device of claim 34, wherein the laser safety module is adapted to receive a fault indication from a component of the projection device and cause an interruption of the laser module in response to the fault indication.

37. The projection device of claim 34, further comprising a proximity sensor operatively connected to the laser safety module, the laser safety module being configured to: receive, from the proximity sensor, a signal indicating a presence of a person in close proximity to the projection device, and cause an interruption of the laser module when the laser safety module interprets the signal indicating the presence of the person in close proximity to the projection device as a safety hazard for that person.

38. A method of operation of the projection device as defined in claim 1, the method comprising: loading a construction plan in the projection device; positioning the projection device on a construction site; initiating the projection of the construction plan on the construction site.

39. The method of claim 38, further comprising providing position and orientation information to the construction site.

40. The method of claim 38, further comprising: configuring at least three reference points on the construction site; and causing the projection device to calculate its position and orientation on the construction site.

41. The method of claim 39, further comprising providing commands to the projection device for controlling the orientation of the projection device.

42. The method of claim 39, further comprising providing a command to the projection device for causing the projection device to track a position of a moving reference device.

43. The method of claim 40, wherein calculating the position and orientation of the projection device on the construction site comprises performing a trilateration of the projection device.

44. The method of claim 38, further comprising providing a command to the projection device for causing the projection device to adjust a pitch angle of the projector head, a yaw angle of the projector head, or at once the pitch angle and the yaw angle of the projector head.

45. The method of claim 38, further comprising calculating a keystone effect compensation for the projection of the construction plan on the construction site.

46. The method of claim 38, further comprising converting the construction plan from a first format to a second format.

47. The method of claim 46, wherein the first format is a standard format and the second format is a proprietary format

48. The method of claim 46, wherein converting the construction plan from the first format to the second format comprises manipulating a content of the construction plan.