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(54) **Title**: A METHOD AND A SYSTEM FOR A WORK MACHINE WITH A BOOM

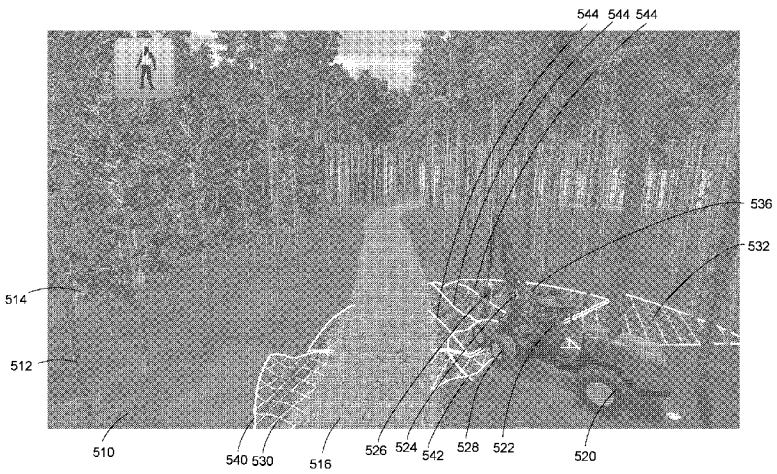


Fig. 5

(57) **Abstract**: The invention relates to a forest machinery or work machinery, especially to a forest machine simulator. The simulator of a forest machine aims to help the user of the simulator by adding visual cues to the simulated environment. The simulator may, for example, add a grid indicating a working area of the simulated forest machine so that the user can see the proper working area on the landscape.

A method and a system for a work machine with a boom

Field of the Invention

The present invention relates to a work machine or a forest machine, especially to a computer-simulated machine in an artificial environment.

Background of the Invention

The development of forest machines has enabled significant improvements in productivity in forest care and harvesting. Modern forest machines are able to work accurately and with high speed, and the output of such machines is known by measurements already at the time the work is being done. The machinery in these sophisticated devices has many innovative solutions that increase safety and productivity of such machines.

Operating a modern forest machine is a demanding task that requires high professional skills. Learning to operate the machine involves both theoretical and practical training. The theoretical training includes e.g. learning to use the right principles at work and understanding the purpose of each phase in the work. Practical training involves learning to operate the physical controls of a forest machine, typically by operating the machine in real nature.

In recent times, it has become possible to practice operating a forest machine by using a simulator. In a very developed simulator, such as the ones available for John Deere® forest machines, the physical controls are the same or at least very much like those in a real forest machine. The operations of the machine are simulated by a computer, and may resemble the operation of a real machine to a good degree. Unfortunately, however good the simulation of the machine itself, the computer-created environment cannot completely correspond to the real world environment in a forest. For example, the perspective of the environment on the computer screen may be more difficult to grasp,

and imagination and spatial abstraction skills may be needed to see the position and operation of the machine in relation to the simulated environment. This challenge is partly created by the limited display means compared to real world sight, but also by other factors.

There is, therefore, a need for a solution that makes it easier for a person to learn how to operate a forest machine in a simulated environment.

Summary of the Invention

Now there has been invented an improved method and technical equipment implementing the method, by which the above problems are alleviated. Various aspects of the invention include a method, an apparatus, a server, a client and a computer readable medium comprising a computer program stored therein, which are characterized by what is stated in the independent claims. Various embodiments of the invention are disclosed in the dependent claims.

The simulator of a forest machine according to various embodiments of the invention aims to help the user of the simulator by adding visual cues to the simulated environment. The simulator may, for example, add a grid indicating a working area of the simulated forest machine so that the user can see the proper working area on the landscape. The grid or other indicator may have a shape that is descriptive of the reach of the forest machine, for example a cone or a rectangle, and it may be attached to the forest machine so that it is able to move with the machine in the simulated environment. The grid may be arranged to be shown on top of the terrain or ground objects of the environment through arrangements in computer graphics. The arrangement according to the invention may help the user to learn proper working methods, e.g. to operate the forest machine so that the working area is on the side of the machine if such operation provides for a better reach and stability.

According to a first aspect, there is provided a method for displaying a working area of a boom pivotally mounted on a work machine at an

apparatus for controlling the boom and/or the work machine, the method comprising electronically determining a dimension of at least part of the working area of the work machine, and electronically indicating the working area of the work machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the work machine.

According to an embodiment, the apparatus for controlling a forest machine is a work machine or a forest machine simulator, and the method further comprises modeling the work machine or forest machine by a computer so that at least one part of the forest machine is a computer-modeled part, and displaying movement of the computer-modeled part of the work machine or forest machine to a user of the apparatus. According to an embodiment, the method further comprises electronically modeling the terrain around the machine with a terrain form, and electronically indicating the working area of the forest machine on top of the terrain form, and electronically indicating the working area with the help of a texture. According to an embodiment, the method further comprises aligning the orientation of the indication of the working area to one of the orientation of the whole machine, the orientation of a part of the machine, the orientation of the cabin or to the orientation of the working means of the machine such as the boom pivot. According to an embodiment, the method further comprises determining information on the forestry task being performed by the user, and electronically indicating the working area of the forest machine based on said information on the forestry task. According to an embodiment, the indication of the working area comprises at least one of the group of indicator for movement track of the machine, indicator for closest reach of working means or the boom, indicator for furthest reach of working means or the boom, positive working area indicator, negative working area indicator, a working cone indicator and a working square indicator, and an asymmetric working area indicator based on attitude and position of the work machine. According to an embodiment, the control means are configured to be used with a simulated machine or a real-world machine. According to an embodiment, the work machine is a real-world work machine such as a forestry machine or a loader having a mechanical boom. According to

an embodiment, the method further comprises indicating the working area using a head-up display.

According to a second aspect, there is provided an apparatus comprising a processor, memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to electronically determine a dimension of at least part of the working area of a boom pivotally mounted on a work machine or a forest machine, and electronically indicate the working area of the machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the machine.

According to an embodiment, the apparatus further comprises computer program code configured to, with the processor, cause the apparatus to model the forest machine by a computer so that at least one part of the forest machine is a computer-modeled part, and to display movement of the computer-modeled part of the forest machine to a user of the apparatus. According to an embodiment, the apparatus further comprises computer program code configured to, with the processor, cause the apparatus to electronically model the terrain around the machine with a terrain form, and electronically indicate the working area of the forest or work machine on top of the terrain form, and electronically indicate the working area with the help of a texture. According to an embodiment, the apparatus further comprises computer program code configured to, with the processor, cause the apparatus to align the orientation of the indication of the working area to one of the orientation of the whole machine, the orientation of a part of the machine, the orientation of the cabin or to the orientation of the working means such as the boom pivot. According to an embodiment, the apparatus further comprises computer program code configured to, with the processor, cause the apparatus to determine information on the forestry task being performed by the user, and electronically indicate the working area of the forest machine based on said information on the forestry task. According to an embodiment, the indication of the working area comprises at least one of the group of indicator for movement track of the machine, indicator for closest reach of working means, indicator for furthest reach of working means, positive working

area indicator, negative working area indicator, a working cone indicator and a working square indicator, and an asymmetric working area indicator based on attitude and position of the work machine. According to an embodiment, the control means are configured to be used with a simulated machine or a real-world machine. According to an embodiment, the work machine is a real-world work machine such as a forestry machine or a loader having a mechanical boom. According to an embodiment, the apparatus further comprises a head-up display for indicating the working area.

According to a third aspect, there is provided an apparatus comprising a processor, memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to perform the method as described in the first aspect. According to an embodiment, the work machine is a real-world work machine such as a forestry machine or a loader having a mechanical boom. According to an embodiment, the apparatus further comprises a head-up display for indicating the working area.

According to a fourth aspect, there is provided a computer program product stored on a computer readable medium and executable in a data processing device, wherein the computer program product comprises a computer program code section for determining a dimension of at least part of the working area of a boom pivotally mounted on a work or a forest machine, and a computer program code section for indicating the working area of the machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the machine.

According to a fifth aspect, there is provided a computer program product stored on a computer readable medium and executable in a data processing device, wherein the computer program product comprises computer program code sections for carrying out the method as described in the first aspect.

According to a fifth aspect, there is provided an apparatus comprising control means of a forest machine or a boom pivotally mounted on a

work machine or a forest machine for receiving control input from a user and producing control signals for controlling the apparatus, means for processing said control signals from the control unit, means for determining a dimension of at least part of the working area of the forest or work machine, and means for indicating the working area of the machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the forest machine. According to an embodiment, the apparatus further comprises means for modeling the machine by a computer so that at least one part of the machine is a computer-modeled part, and means for displaying movement of the computer-modeled part of the forest machine to a user of the apparatus.

According to a sixth aspect, there is provided a system comprising at least a first apparatus and a second apparatus according to the first, second and/or fifth aspect, wherein the first apparatus and the second apparatus are connected with a data connection, and the first apparatus and the second apparatus are configured to show information indicative of the operation of the second apparatus at the first apparatus. According to an embodiment, the first apparatus is configured to display the graphical form of the second apparatus in the virtual scenery of the first apparatus.

According to a seventh aspect, there is provided a system comprising at least a first apparatus and a second apparatus according to the second aspect, wherein the first apparatus and the second apparatus are connected with a data connection, and the first apparatus and the second apparatus are configured to show information indicative of the operation of the second apparatus at the first apparatus.

According to an embodiment, the work machine is configured to indicate the working area in response to operating the boom, and to remove the working area indicator when the boom is not being operated. According to an embodiment, the work machine further comprises a head-up display for indicating the working area.

According to an eighth aspect, there is provided a work machine such as a forestry machine comprising a movable boom, a display, a processor, memory including computer program code, the memory and the computer program code configured to, with the processor, cause the work machine to electronically indicate a working area of the boom on the display. According to an embodiment, the work machine is configured to indicate the working area in response to operating the boom, and to remove the working area indicator when the boom is not being operated. According to an embodiment, the work machine comprises a head-up display for indicating the working area.

Description of the Drawings

In the following, various embodiments of the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 shows a flow chart of the operation of a forest machine according to an embodiment of the invention;

Fig. 2 shows a flow chart of the operation of a forest machine according to an embodiment of the invention;

Figs. 3a and 3b show a forest machine simulator according to an embodiment of the invention;

Fig. 4 shows a block diagram of a forest machine simulator according to an embodiment of the invention;

Fig. 5 shows a simulated view of the forest machine simulator according to an embodiment of the invention;

Figs. 6a and 6b show schematic representations of different working area indicators for the forest machine according to an embodiment of the invention;

Fig. 7 shows a view of the forest machine in training mode according to an embodiment of the invention;

Fig. 8 shows a view of editing a simulated terrain in the forest machine for the training mode according to an embodiment of the invention; and

Figs 9a and 9b show two types of forest machines whose operation can be modeled in the simulator according to an embodiment of the invention.

Fig. 10 shows an example of displaying a working area of a work machine on a display inside the working machine.

Fig. 11 shows an example of using a head-up display for indicating the working area of a work machine in the real world.

Detailed Description of the Embodiments

In the following, several embodiments of the invention will be described in the context of a forest machine or generally work machine. It is to be noted, however, that the invention is not limited to forest machines alone. In fact, the different embodiments have applications widely in any environment where indicating the working area of a machine is required. For example, different kind of machines like cranes, loaders, agriculture machines and such may benefit from indication of the working area according to the invention. The working area especially needs to be indicated when the work machine or forest machine has a boom that may change in length or may otherwise be arranged to be able to reach at different distances from the work machine. The boom may be arranged so that there is a boom pivot around which the boom can rotate.

Fig. 1 shows a flow chart of the operation of a forest machine according to an embodiment of the invention. A forest machine typically has a boom or another kind of an arrangement to bring the saw head of the machine to a tree. The boom may be arranged to change length as needed, for example by comprising two or more parts connected by a joint. This allows the saw head to be brought close to the machine by closing the angle in the joint, and far away from the machine by opening the angle. The boom therefore has a certain range of operation.

Different methods of working may also define different optimal ways of working with the boom and the saw head. For example, it may be advantageous and efficient to cut trees from the side of the machine, and not cutting trees from the front. The trees in the front will come to the optimal range of operation and the optimal direction of working (to the side of the machine) when the machine moves forward. Therefore, a working method may also define an optimal area of working. The working area indicators may help to learn how to position the machine correctly in relation to the trees or cut trunks, as explained later in more detail. For example, a loading machine may be positioned appropriately to the side of a pile of cut trunks.

In Fig. 1, the dimensions (or at least one dimension) of the working area are first determined in step 110. This may happen so that a computer has predefined information about the working area in numeric format, or has a predefined working area pattern stored in its memory. When the dimensions of the working area are known, the working area can be indicated on top of the terrain surrounding the forest machine in step 120. This may happen e.g. by projecting a graphical pattern comprising lines and shapes onto the terrain by using graphical abilities of the computer. The projection may happen inside the virtual world of the computer, or projection means such as a head-up display may be used in a real world.

Fig. 2 shows a flow chart of the operation of a forest machine according to an embodiment of the invention. In step 210, the forest machine is modeled with a computer. The model may comprise

mechanical modeling, operational modeling of the engine, controls, boom and saw head and graphical modeling. This modeling of the forest machine acts as a basis for displaying the movement of the machine in step 220. For example, the movement of the boom may affect stability of the machine, and hitting objects may cause sounds to be produced.

In step 230, the task given to the user of the simulator is determined. More specifically, the parameters for success and the teaching goals of the task may be determined. This determination may happen e.g. by user input, or these data may be loaded from the computer memory. As explained earlier, the work area may be determined based on the task at hand in step 240, for example, the specific task parameters. The work area may also be determined without using information of the specific task, e.g. purely depending on the forest machine being used. When the working area is known, the dimensions of the working area may be determined in step 250. This may comprise e.g. computing the size of the working area or the zoom size of the working area template. In step 260, the working area is aligned with the forest machine so that the working area corresponds to the situation in the real world. The working area may also depend on the position, attitude and/or tilt of the work machine so that work areas on different sides of the machine are of different size and/or shape. For example, the working area below the machine on a side of a hill may be smaller than the working area above the machine. This may be done e.g. to increase the stability of the machine.

Modeling the terrain with a terrain form in step 270 is one example of how the working area can be displayed on the terrain. The terrain form may e.g. be a triangle mesh or another shape that is able to lay on top of the terrain in the model. The terrain form may be adjusted to be slightly on top of the terrain so that an opaque terrain form would mask the underlying terrain. In step 280, a texture or other graphical element may be determined, e.g. loaded from a file or generated by an algorithm. The texture or graphical element indicates the working area and may contain e.g. a shape of a cone or a rectangle, as well as color or hash fill. The texture may then be mapped to the terrain form for

showing the working area. This mapping may happen so that points of the texture are assigned to points of the terrain form, and the texture is stretched onto the terrain form. When the texture is displayed in step 290, the resulting view is that the texture indicating the working area seems to be floating or drawn on top of the terrain and the working area is aligned to the position and attitude of the forest machine.

Figs. 3a and 3b show a forest or work machine simulator according to an embodiment of the invention. The simulator is used to teach a person the operation and work methods of a real forest machine. Real forest machines are expensive, and operating them needs to be done in a proper environment, i.e. forest. The teaching use of these expensive machines takes them away from productive work of forest harvesting. Furthermore, the conditions in a forest may often be harsh and impede learning. Due to safety requirements, only one learner can be instructed at a time in real world forest machine. For these and other reasons, simulators like the one in Fig. 3 have been built for teaching purposes.

A forest machine simulator comprises controls 310 and 312 that can be operated by the user. These controls resemble the real controls of a forest machine, or they can be identical to them. Likewise, the seat 320 of the simulator may be a real seat used in a forest machine. The simulator logic 330 is built to be moved with the simulator e.g. under the seat. The display 340 may be a regular computer display in the front of the user. The simulator has been built to be movable, and it may contain handles 350 and wheels 352 for moving it around.

A forest machine like the one in Figs. 3a and 3b may be used to teach work methods of forestry to the user. In forestry, there are many concepts like work location and work direction that may be difficult to understand and visualize in real terrain. Furthermore, the task at hand, when teaching happens on a real machine, can be easily forgotten. On a simulator, the teaching situation and instructions for the task can be shown as a reminder to the student. This is a marked improvement to teaching in real world, where the task is often given by oral and written instructions. Yet, as shown in Figs. 3a and 3b, a simulator may give a

very real learning experience to a user. For example, the simulator may comprise an ignition system 360 like an ignition system in a real forest machine, and it may comprise hand controls 310 and 312 as well as foot controls 370 (brake) that are very much like or exactly the same as in a real forest machine.

Fig. 4 shows a block diagram of a forest machine simulator according to an embodiment of the invention. The controller 410 of the simulator may comprise e.g. the controls 415 and some control logic 418 for creating control signals to the machine. The controls 415 may be similar to the controls of a real forest machine, they may be a simplified version of the real controls, or e.g. regular computer controls may be used. The control logic may include circuitry and/or software on a processor like a microcontroller for generating signals according to the controls operated by the user. The interface to the simulator 440 from the controller 410 may be the same or highly similar to the interface between a real forest machine and its controller.

The simulator 440 is connected to the controller 410 via signal lines. For handling the signals to/from the signal lines, the simulator comprises I/O circuitry 441. The simulator may also comprise an input block 442 for accepting input from the user e.g. through a keyboard and a mouse. The simulator comprises a processor 445 and memory 446 for running and storing computer program code for the simulator operations. There may be multiple processors e.g. a general purpose processor and a graphics processor and/or multiple different memories e.g. volatile memory for storing data and programs at run-time and nonvolatile memory like a hard disk for permanently storing data and programs. The simulator may also include a video controller 448 and an audio controller 449 for generating signals that can be produced to the user with computer accessories.

There may also be multiple simulators connected to each other over a wireless or wired network (not shown). In such a system a first simulator and a second simulator may be connected with a data connection so that the second apparatus can send information to the first apparatus, and the first apparatus may show this information to the

user or use it in the modeling of the scenery. For example, performance data of the second apparatus may be shown at the first apparatus. Also, the second apparatus may appear as a graphical form in the virtual scenery of the first apparatus. This may give a view to the user that there is another machine working in the same area, and the user may see this other machine moving and working. Such a system may also be used in a teaching purpose where a teacher or a supervisor is able to observe any single machine or multiple machines working in the environment. Practically, the first machine may be a harvester machine and the second machine may be a loader machine.

The simulator produces output to the user through output means 470. The video controller 448 may be connected to a display 475. The display may be e.g. a flat panel display or a projector for producing a larger image. The display may also be adapted to wearable video goggles. The audio controller 449 may be connected to a sound source 478 such as loudspeakers or earphones.

Fig. 5 shows a simulated view of the forest machine simulator according to an embodiment of the invention. In the simulated view, there are various modeled objects placed onto the terrain 510, for example trees 512 that are the target of the forest machine, and other objects like rocks 514 and roads 516. The terrain may have shapes e.g. ditches like those next to the road 516 and elevation variations like hills. The forest machine itself may comprise two main parts 520 (rear body) and 522 (front body), with the boom 524 attached e.g. to the front part and having a saw head 526. The forest machine may run on wheels 528.

The working area indicators 530, 532 and 536 are projected around the forest machine. The working area indicators 530 and 532 show optimal working areas on the side of the machine, and the working area indicator 536 shows a sub-optimal working area in the front. The working area indicators may comprise elements 540 and 542 to indicate the furthest and closest reach of the boom, respectively. The movement track of the forest machine may also be indicated with the

working area indicators with track signs 544 for showing the width of the needed track when the forest machine moves forward.

The working area indicators are assigned or otherwise moving with the machine, i.e. at least somewhat attached to the machine coordinate system. For example, the working area indicator center point may be attached to the boom pole center point i.e. the axis of the pole bearing of the boom 524. Further, the orientation of the working area indicators may be aligned with the front body 522 of the harvester machine i.e. the same body where the boom 524 is attached or to the boom pivot point (the bearing housing). In a loader machine, the working area indicators may be aligned with the back body of the machine, since the pole is mounted to the back body in a loader machine. The center point of the working area indicators may be arranged to shift e.g. when the machine is tilted or some other conditions are present. The alignment of the working area indicators may also be done in a flexible manner with reference to multiple elements, like the front body 522 and the rear body 520 together, or the alignment may change with the tilting of the machine, ground shapes and so on. The working area indicators may comprise different radiuses, different shapes, circular cones, elliptic cones, squares, and zones of any kind. Colors can be used to indicate a positive or optimal working area and a negative or sub-optimal working area. The working area indicators or parts of the indicators may be labeled with letters, numbers, words, icons or other labels. For example, squares of the working area indicator may receive labels like “A1”, “A2”, …, “A12”, “B1”, “B2” …, “L11” and “L12”. The tasks at hand may then refer to these labels to guide the student. Typically, the boom has a better reach from the side of the machine, and with the help of the working area indicators, this can be now taught at the simulator. The right working methods and work order can be taught with the help of the working area indicators, as well. For a loader machine, the working area indicator may helping to operate the loader in a stable way so that the danger of tipping the machine is smaller.

The working areas may be different for different tasks, e.g. for loading and unloading. There may be a warning displayed if the user tries to reach too far or outside the good working area. The working area

indicators may depend on the teaching level, e.g. narrower working areas may be used for advanced students. It is also possible to give points for working on the optimal working area. There may also be different working area indicators, different sizes and shapes to choose from depending on the task. The working area indicator may comprise reminders of the task at hand like text, numbers or icons, e.g. “Pile here” or “Cutting area” or “Loading zone”. Such reminders or guides may help e.g. to place the cut trees to the right place by the harvester (to the side or to the front), or they may guide to place the left-over branches to a certain area. The guide may also help to position the harvester or the loading machine correctly, or the guide may indicate an area for loading. For example, the working area indicator may turn to green or may blink when the machine has been positioned correctly according to a given task.

As described earlier, textures may be used in showing the working area. The texture may be attached on a terrain form, or it may be attached to the ground object directly. The terrain form is a floating intermediary object following the ground on top of which the texture is attached. The terrain form is placed upwards in z-direction from the ground or towards the viewer in line of sight. The terrain form may “dive” inside objects on terrain, or it may be shown on top of the objects. The terrain object may follow the ground carefully, as seen in context of the ditch next to the road in Fig. 5.

The working area indicator may help learning in several ways. The working area indicator and instructions regarding the given task may stay on screen for the whole learning session. The working area indicator guides the learning so that the student learns to operate the machine right. The indicator can be switched on and off easily, and it may be applied to many different machines. The indicator helps to visualize the scene where 3-dimensional cues are missing due to the limited display arrangement (2-dimensional display). The indicator improves perspective and gives a better estimation what will be at the reach of the machine. In the simulator, learning to reach to the side is normally slightly difficult since the screen is in the front. The working

area indicator helps to guide the student to operate on the side of the machine.

Figs. 6a and 6b show schematic representations of different working area indicators for the forest machines according to an embodiment of the invention. In Fig. 6a, the working areas for the harvester with two main parts 601 and 602 are shown. The reach of the boom 603 may be shown with a cone-shaped indicator 610, 612 (side working areas) and 630 (front working area). The furthest reach of the boom 603 may be shown with arcs 614 and 626, as well as the closest reach with 616 and 622. There may be other indicators for showing an optimal range of the boom such as the area between arcs 618 and the arc 624. The track of the machine for moving forward may be shown with the front working area. There may also be a negative working area shown such as the back working area 640 where the boom cannot or should not reach.

The different working area indicators may have sub-areas, and these sub areas may be labeled. For example, as shown in Fig 6a, the left working area may be divided to sections L1, L2, L3, L4 and L5, the right working area may be divided to sections R1, R2, R3, R4 and R5, the front working area may be divided to sections F1, F2 and F3 and the back working area may be divided to sections B1, B2 and B3. These labels may then be used in e.g. guiding the task at hand by referring in the instructions or scoring to these labels. An asymmetric working area indicator based on attitude and position of the work machine may also be used.

In Fig. 6b, working areas for a loader comprising two main parts 651 and 652 are shown. These working areas may be cone-shaped as above or reactangular areas 660 and 662 as shown in the figure. The working area indicators may have labeled squares or other tagged locations for guiding the work even more accurately. Tagging can be achieved with numbers, letters, text or color. Sound indicators can also be used. The working area indicators may comprise multiple smaller parts that are then selected to form the whole indicator for a given task. The indicators may also be shaped by hand, e.g. by stretching from an

original form or drawing. As described earlier, the different working areas may be subdivided to sections and these sections may be labeled e.g. with labels like “A1” to “L12”. These labels may then be used in e.g. guiding the task at hand by referring in the instructions or scoring to these labels.

Fig. 7 shows a view of the forest machine in training mode according to an embodiment of the invention. In addition to the visible results of the work like cut trees 710, the training mode provides a clear scoring system that can be defined to follow the student’s progress. There may be different criteria 720 according to which the performance is judged. These criteria are measured with values 730, and from the values, scores 740 for the criteria are computed. The total score is an indicator of the student’s performance. Different performance criteria have been listed in Table 1.

Table 1. Performance criteria

Total time	Drive over logs	Cabin damage	Pine stem count
Log volume	Machine damage	Boom to trees	Spruce stem count
Mean stack size	Damaged trees	Boom other damage	Birch stem count
Mean stack quality	Saw damage	Rotten log count	Aspen stem count

The use of working area indicators may provide advantages for learning. For example, a good working method can be trained by the simulator. The trees are removed from the side, not from the front. The trees in the front will come to optimal working area (side) when the machine moves forward. As another example, the needed driving track (width) can be shown, and minimum and maximum reach of the boom, as well as an optimal operating range are shown. The use of working area indicator makes it possible to continue the learning in a simulator for a longer time without the need to move to a real machine, since less “false learning” happens. This may provide cost savings and accelerate learning.

The working area indicator may also help to learn the reach of the boom so that this knowledge is then usable in real world. The working

area indicator helps to understand the effect of the boom to machine stability – in a simulator, this is otherwise challenging to understand for a student. Visible information on widths and radiuses helps to learn proper positioning of the harvester machine and proper use of boom in a loader machine.

Fig. 8 shows a view of editing a simulated terrain in the forest machine for the training mode according to an embodiment of the invention. The simulator software may comprise, for example, the following three modes that can be implemented as separate, interconnected programs or different views in a single program, or any combination of the same. The first mode may include editors for the surrounding terrain, trees, roads and other objects in the scenery – it may be called a scenery editor. The scenery editor allows to shape the terrain in terms of surface elevation, and it allows to position different objects onto the terrain (or possibly into the terrain). The different objects may be positioned either automatically or manually, or semi-automatically as a group. The scenery editor may allow loading a pre-created scenery from a file, and it may allow storing a part of the scenery or the whole scenery to a file for later use. The second mode may be a scoring editor, where points for different operations can be defined. The third mode may be the simulation mode, as shown e.g. in Fig. 5.

In Fig. 8, the editor has a terrain 810 where different objects can be placed. There may be trees, rocks and other objects 840 on the map. Roads 820 and terrain forms 830 can be created onto the map. There are buttons for adding different objects like groups of trees 842, electric lines 844, surface forms 846 and roads 848. The scenery can be created manually e.g. tree-by-tree or semi-automatically e.g. as groups of trees filling a certain area and having a certain density characteristics. The benefit of such a terrain editor is that teaching scenes can be created beforehand and stored for later use. Since the forest exists in the computer, it can be grown back in a few seconds after being cut. The computerized teaching material therefore stays up to date and can be easily reused.

Figs 9a and 9b show two types of forest machines whose operation can be modeled in the simulator according to an embodiment of the invention. In Fig. 9a, a harvester is shown, comprising two main parts, the engine part 910 and the cabin part, connected with a swivel 925. The harvester may have wheels 930 to run on the terrain, or other means of supporting it on the ground. The harvester has a boom with a saw head for cutting the trees and delimbing them. In Fig. 9b, a loader machine for transporting the trunks from the forest is shown. The loader machine has two parts, the cabin part 950 and the cage part 960. The loader machine has a boom and a grabber head attached to the boom for collecting the trunks to the cage 980. The loader machine may also run on wheels 990. Other types of machines are also possible in the simulator.

Fig. 10 shows an example of displaying a working area of a work machine on a display inside the working machine. The display is arranged to show to the operator of the work machine information on the work machine status 1030 as well as information on the task at hand 1040, 1050 and 1055. For example, the display may show the engine and battery status of a forest machine or a harvester, and it may indicate to the operator the dimensions of the tree being cut and the kind of tree being cut (e.g. here “KUUSI” or “SPRUCE”). In order to help operating the machine, the display may be adapted to show the working area indicators on the screen. There may also be information like the operator’s name (here “Pekka”), and the machine may record the produced output related to the person operating the machine, allowing multiple persons to successively operate the machine.

The display may show the position and attitude of the machine 1010, as well as the direction, length and movement of the boom 1095. The left working area 1025, the right working area 1020 as well as the front working area 1022 may be indicated, with the respective sub-areas and the sub-area labels. Showing the working area indicators on the screen may help the operator to operate the machine optimally. The terrain may be shown in the work area indicator on the screen with the help of camera or scanner means, e.g. attached to the boom. The working area indicator may also be shown on the real controller screen in a

simulator, in addition to showing the working area indicators in the simulated world.

The working area indicator may also be brought to the screen at times when the boom is being moved by the operator, and removed from screen at other times. This helps to use the display space optimally and allows the operator to observe only the most important matters on the screen. For example, when the tree is being cut, and the boom is not moving, the operator may appreciate to see the data related to the cutting. Therefore, at times when the tree is being cut, indicators like the length of the trunk and volume of prepared logs may be shown. At times of other operations, other data may be shown, and the working area indicator may be removed from the screen or minimized to occupu less screen area. When the operator is moving the boom, the working area indicator may be brought onto the screen, or it may be enlarged from a small indicator to a larger indicator to be better visible, or the working area indicators may fill essentially the entire screen. Showing the boom movement and position may require sensors on the boom for sensing the direction, length (extension) and movement of the boom.

Fig. 11 shows an example of using a head-up display for indicating the working area of a work machine in the real world. The operator of the work machine may have been trained in a simulator by showing the working area indicators in the simulated world, and possibly at the same time on the real controller screen as explained with reference to Fig. 10. The real work machine, like a forest machine or a harvester or a loader machine, may be fitted with a head-up display for showing the working area indicators familiar from the training indicator.

The real work machine has a cabin with windows 1110 (right window), 1120 (left window) and 1130 (front window). The work machine may have the same controls 1140, 1145, and 1150 as in the simulator, and the control screen 1145 may show the same working area indicators as in the simulator. To even further improve the usefulness of the working area indicators, they may be shown projected onto the windows with the help of head-up displays. There may be multiple head-up displays, for example three or four or more, or just one.

In an exemplary setup, the right working area indicator 1118 is projected onto the right window 1110 with the help of a head-up display 1115. The left working area indicator 1128 is projected onto the left window 1120 with the help of a head-up display 1125. The front working area indicator 1138 is projected onto the front window 1130 with the help of a head-up display 1135. This way, the working area indicators may be seen by the operator as if they were on top of the terrain. The head-up displays may be adapted to take into account the height of the operator so that the working area indicators are seen at the right place on top of the terrain. The head-up displays may also be able to adapt to the movement of the operator's head, and they may adapt to the tilt of the machine by changing the projection onto the window.

Other arrangements for projecting the working area indicators onto the terrain in the visual field of the operator may be used. Basically, any means that are able to form an image of the working area indicators so that it appears to be on top of the terrain may be used. Such arrangements may be a special helmet that follows head movements, transparent video goggles that detect how the operator is oriented, or even ray projection arrangements may be used. The image may be formed on any surface, even directly on the surface of the eye's retina.

The various embodiments of the invention can be implemented with the help of computer program code that resides in a memory and causes the relevant apparatuses to carry out the invention. For example, a terminal device may comprise circuitry and electronics for handling, receiving and transmitting data, computer program code in a memory, and a processor that, when running the computer program code, causes the terminal device to carry out the features of an embodiment. Yet further, a network device may comprise circuitry and electronics for handling, receiving and transmitting data, computer program code in a memory, and a processor that, when running the computer program code, causes the network device to carry out the features of an embodiment.

It is obvious that the present invention is not limited solely to the above-presented embodiments, but it can be modified within the scope of the appended claims.

Claims:

1. A method for displaying a working area of a boom pivotally mounted on a work machine at an apparatus for controlling the boom and/or the work machine, the method comprising:
- electronically determining a dimension of at least part of the working area of the work machine, and
- electronically indicating the working area of the forest machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the work machine.

2. A method according to claim 1, wherein the apparatus for controlling a forest machine is a forest work machine simulator, the method further comprising:
- modeling the forest work machine by a computer so that at least one part of the forest machine is a computer-modeled part, and
- displaying movement of the computer-modeled part of the forest work machine to a user of the apparatus.

3. A method according to claim 1 or 2, further comprising:
- electronically modeling the terrain around the work machine with a terrain form, and
- electronically indicating the working area of the work machine on top of the terrain form, and
- electronically indicating the working area with the help of a texture.

4. A method according to claim 1, 2 or 3, further comprising:
- aligning the orientation of the indication of the working area to one of the orientation of the whole machine, the orientation of a part of the machine, the orientation of the cabin or to the orientation of the boom pivot.

5. A method according to any of the claims 1 to 4, further comprising:
- determining information on the forestry task being performed by the user, and
- electronically indicating the working area of the forest machine based on said information on the forestry task.

6. A method according to any of the claims 1 to 5, wherein said indication of the working area comprises at least one of the group of indicator for movement track of the machine, indicator for closest reach of the boom, indicator for furthest reach of the boom, positive working area indicator, negative working area indicator, a working cone indicator, a working square indicator, and an asymmetric working area indicator based on attitude and position of the work machine.

7. A method according to any of the claims 1 to 6, wherein the control means are configured to be used with a simulated machine or a real-world machine.

8. An apparatus comprising a processor, memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to perform at least the following:
- electronically determining a dimension of at least part of the working area of a boom pivotally mounted on a work machine, and
- electronically indicating the working area of the work machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the work machine.

9. An apparatus according to claim 8, further comprising computer program code configured to, with the processor, cause the apparatus to perform at least the following:
- modeling the work machine by a computer so that at least one part of the work machine is a computer-modeled part, and
- displaying movement of the computer-modeled part of the work machine to a user of the apparatus.

10. An apparatus according to claim 8 or 9, further comprising computer program code configured to, with the processor, cause the apparatus to perform at least the following:
- electronically modeling the terrain around the machine with a terrain form, and

- electronically indicating the working area of the machine on top of the terrain form, and
- electronically indicating the working area with the help of a texture.

11. An apparatus according to claim 8, 9 or 10, further comprising computer program code configured to, with the processor, cause the apparatus to perform at least the following:
- aligning the orientation of the indication of the working area to one of the orientation of the whole machine, the orientation of a part of the machine, the orientation of the cabin or to the orientation of the boom pivot.

12. An apparatus according to any of the claims 8 to 11, further comprising computer program code configured to, with the processor, cause the apparatus to perform at least the following:
- determining information on the forestry task being performed by the user, and
- electronically indicating the working area of the forest machine based on said information on the forestry task.

13. An apparatus according to any of the claims 8 to 12, wherein said indication of the working area comprises at least one of the group of indicator for movement track of the machine, indicator for closest reach of working means, indicator for furthest reach of working means, positive working area indicator, negative working area indicator, a working cone indicator and a working square indicator, and an asymmetric working area indicator based on attitude and position of the work machine.

14. An apparatus according to any of the claims 8 to 13, wherein the control means are configured to be used with a simulated machine or a real-world machine.

15. An apparatus comprising a processor, memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to perform the method according to any of the claims 1 to 7.

16. A computer program product stored on a computer readable medium and executable in a data processing device, wherein the computer program product comprises
- a computer program code section for determining a dimension of at least part of the working area of a boom pivotally mounted on a work machine, and
- a computer program code section for indicating the working area of the work machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the work machine.

17. A computer program product stored on a computer readable medium and executable in a data processing device, wherein the computer program product comprises computer program code sections for carrying out the method according to any of the claims 1 to 7.

18. An apparatus comprising:
- control means of a boom pivotally mounted on a work machine for receiving control input from a user and producing control signals for controlling the apparatus,
- means for processing said control signals from the control unit,
- means for determining a dimension of at least part of the working area of the forest machine, and
- means for indicating the working area of the work machine so that the indication of the working area is at least partly visible on top of a terrain adjacent to the forest machine.

19. An apparatus according to claim 18, further comprising:
- means for modeling the forest machine by a computer so that at least one part of the work machine is a computer-modeled part, and
- means for displaying movement of the computer-modeled part of the work machine to a user of the apparatus.

20. A system comprising at least a first apparatus and a second apparatus according to any of the claims 8 to 15, wherein the first apparatus and the second apparatus are connected with a data connection, and the first apparatus and the second apparatus are

configured to show information indicative of the operation of the second apparatus at the first apparatus.

21. A system according to claim 20, wherein the first apparatus is configured to display the graphical form of the second apparatus in the virtual scenery of the first apparatus.

22. A method according to any of the claims 1 to 7, wherein the work machine is a real-world work machine such as a forestry machine or a loader having a mechanical boom.

23. A method according to claim 22, further comprising indicating the working area using a head-up display.

24. An apparatus according to any of the claims 8 to 15, wherein the work machine is a real-world work machine such as a forestry machine or a loader having a mechanical boom.

25. An apparatus according to claim 24, further comprising a head-up display for indicating the working area.

26. A work machine comprising a movable boom, a display, a processor, memory including computer program code, the memory and the computer program code configured to, with the processor, cause the work machine to perform at least the following:
- electronically indicating a working area of the boom on the display.

27. A work machine according to claim 26, the work machine is configured to indicate the working area in response to operating the boom, and to remove the working area indicator when the boom is not being operated.

28. A work machine according to claim 26 or 27, further comprising a head-up display for indicating the working area.

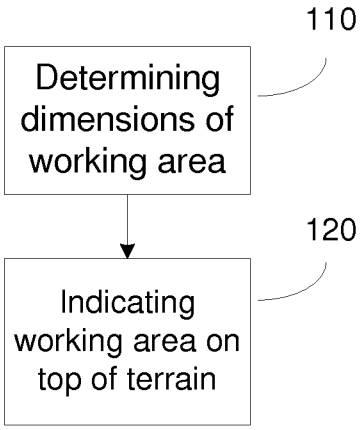

110
Determining dimensions of working area
120
Indicating working area on top of terrain

Fig. 1

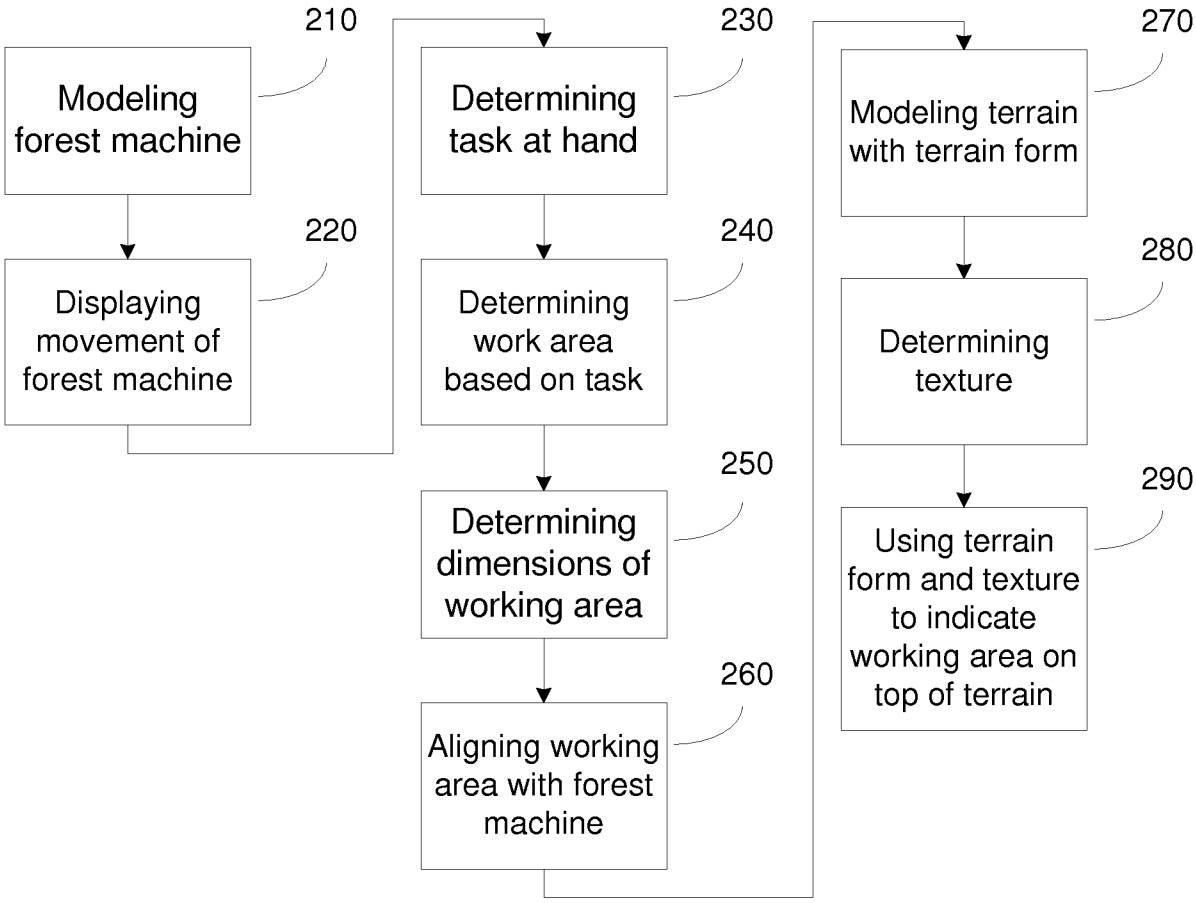

210
Modeling forest machine
220
Displaying movement of forest machine
230
Determining task at hand
240
Determining work area based on task
250
Determining dimensions of working area
260
Aligning working area with forest machine
270
Modeling terrain with terrain form
280
Determining texture
290
Using terrain form and texture to indicate working area on top of terrain

Fig. 2

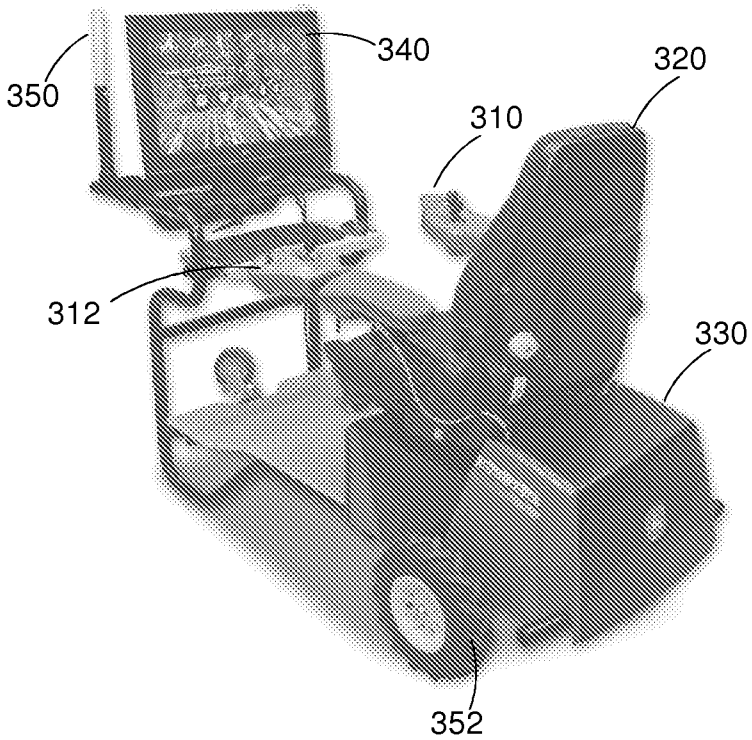


Fig.3a

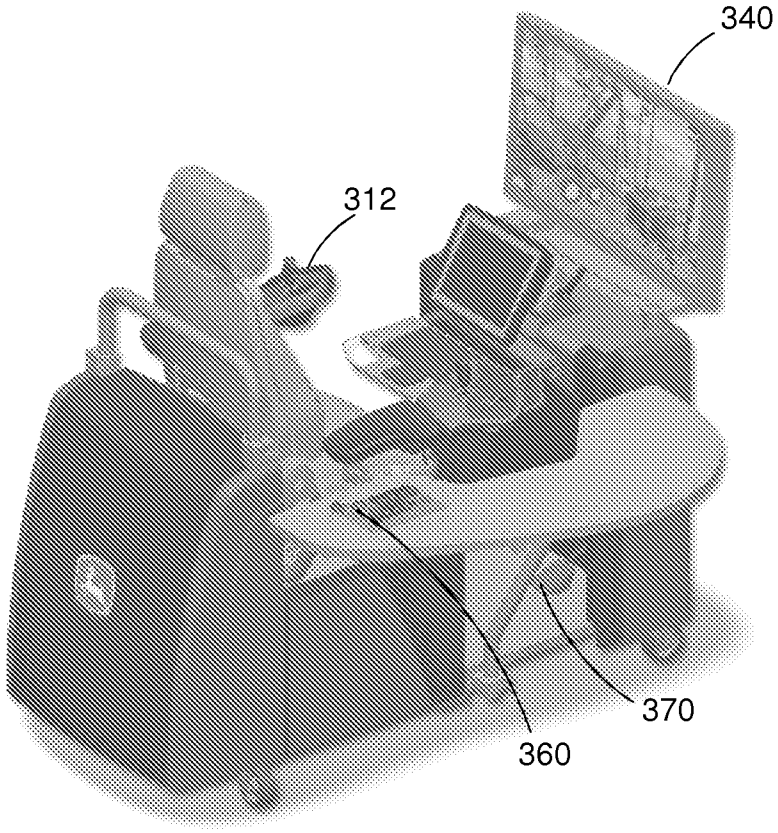
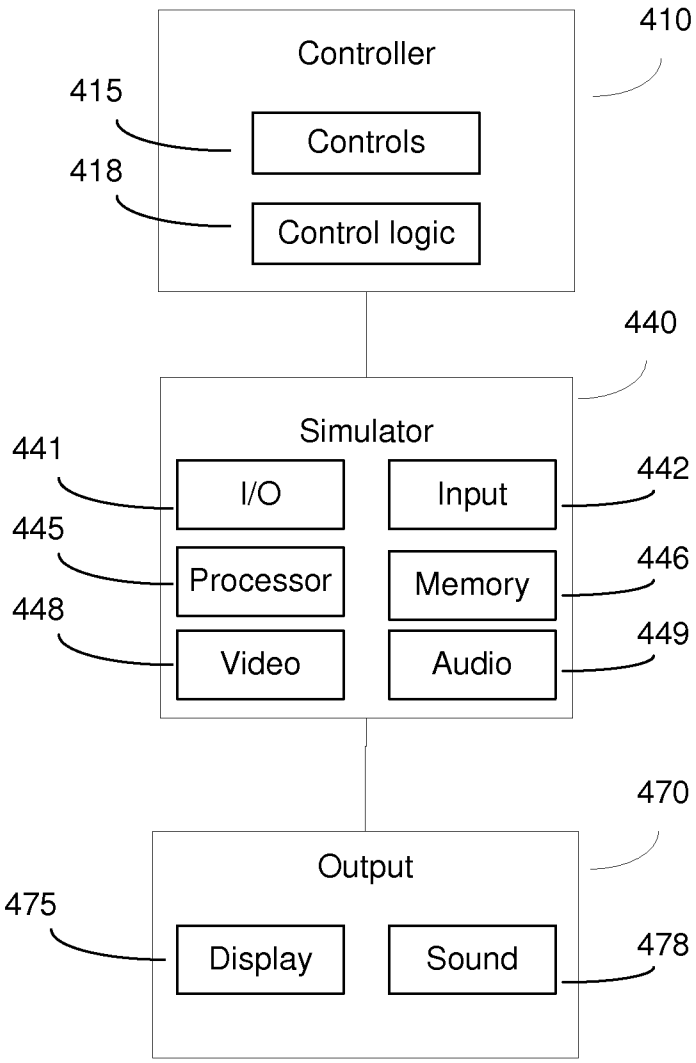


Fig. 3b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Controls
418
Control logic
440
Simulator
441
I/O
Input
442
445
Processor
Memory
446
448
Video
Audio
449
470
Output
475
Display
Sound
478

Fig. 4

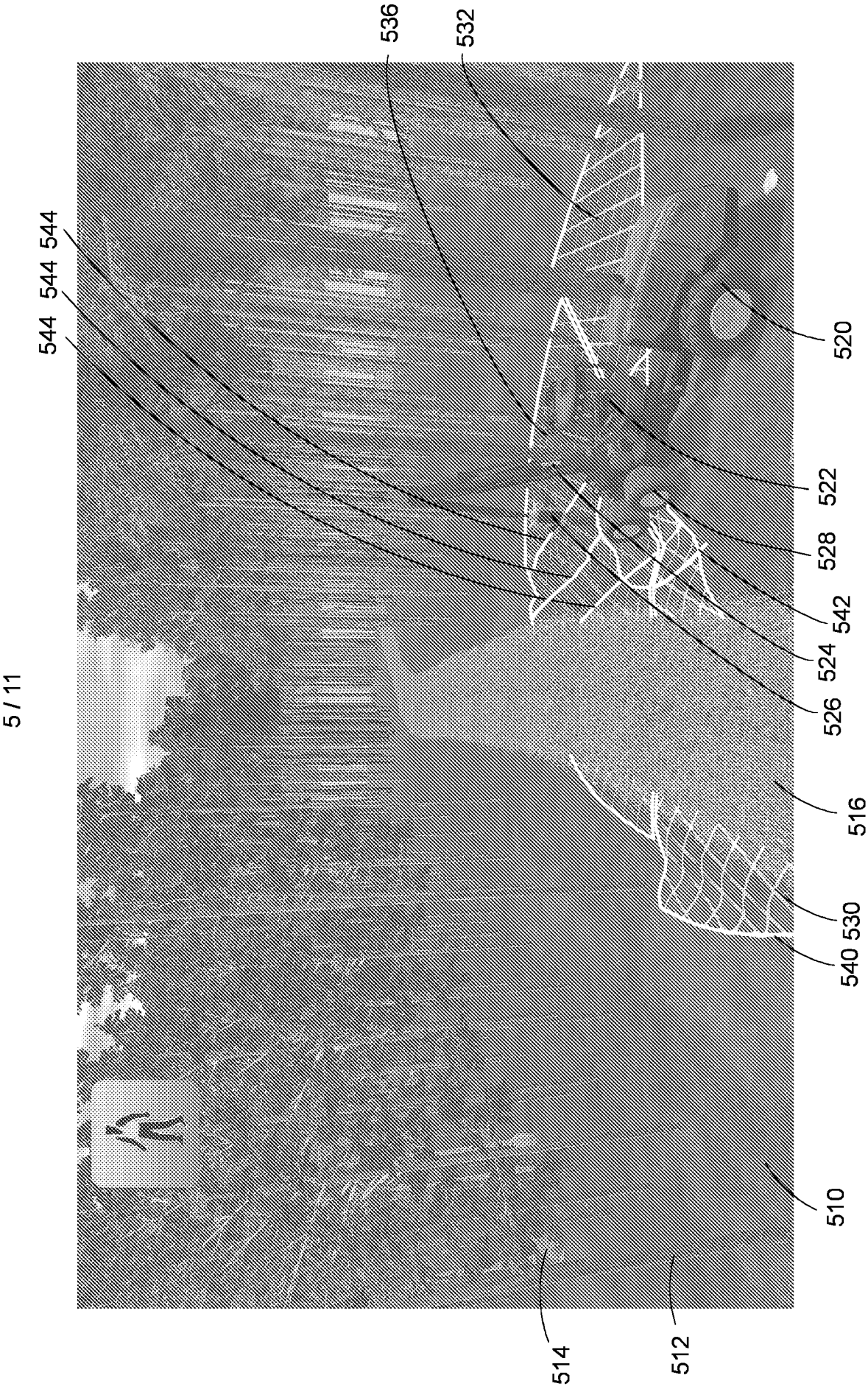
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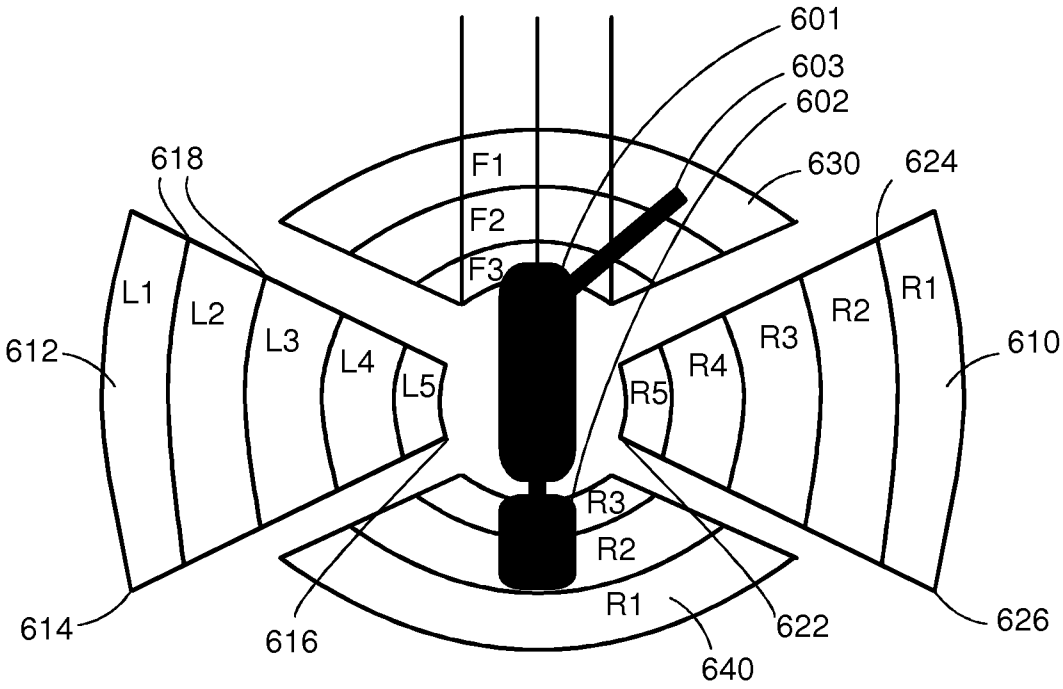
Fig. 5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L4
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R2
R1
614
616
622
626
640

Fig. 6a

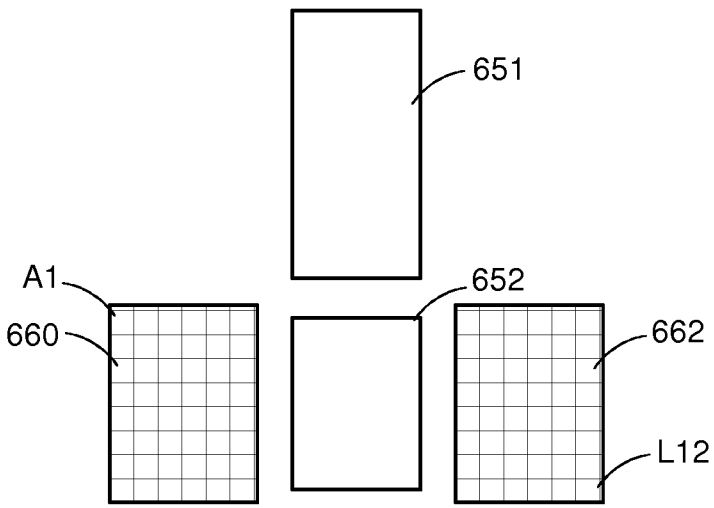
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Fig.6b

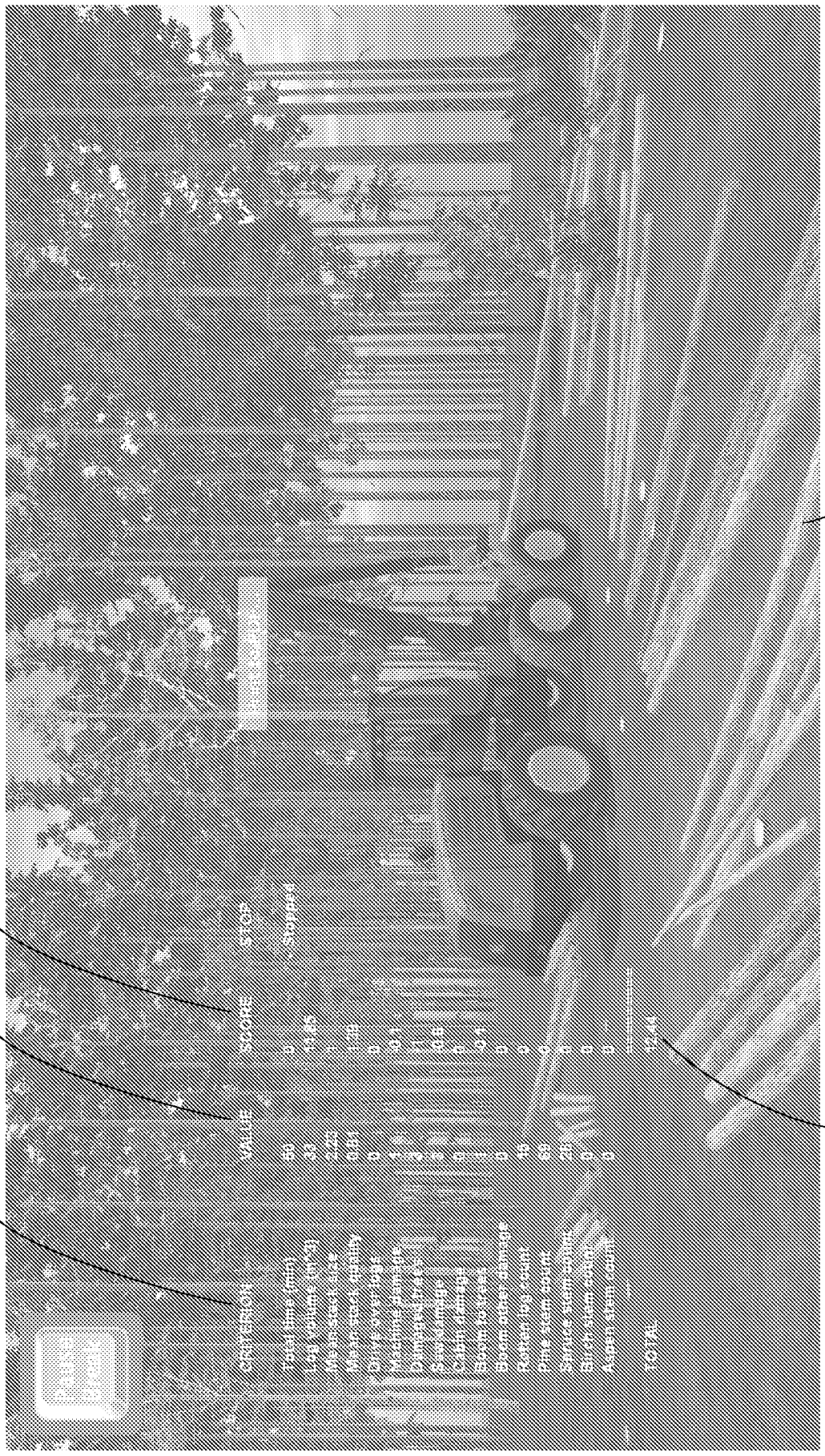


Fig. 7

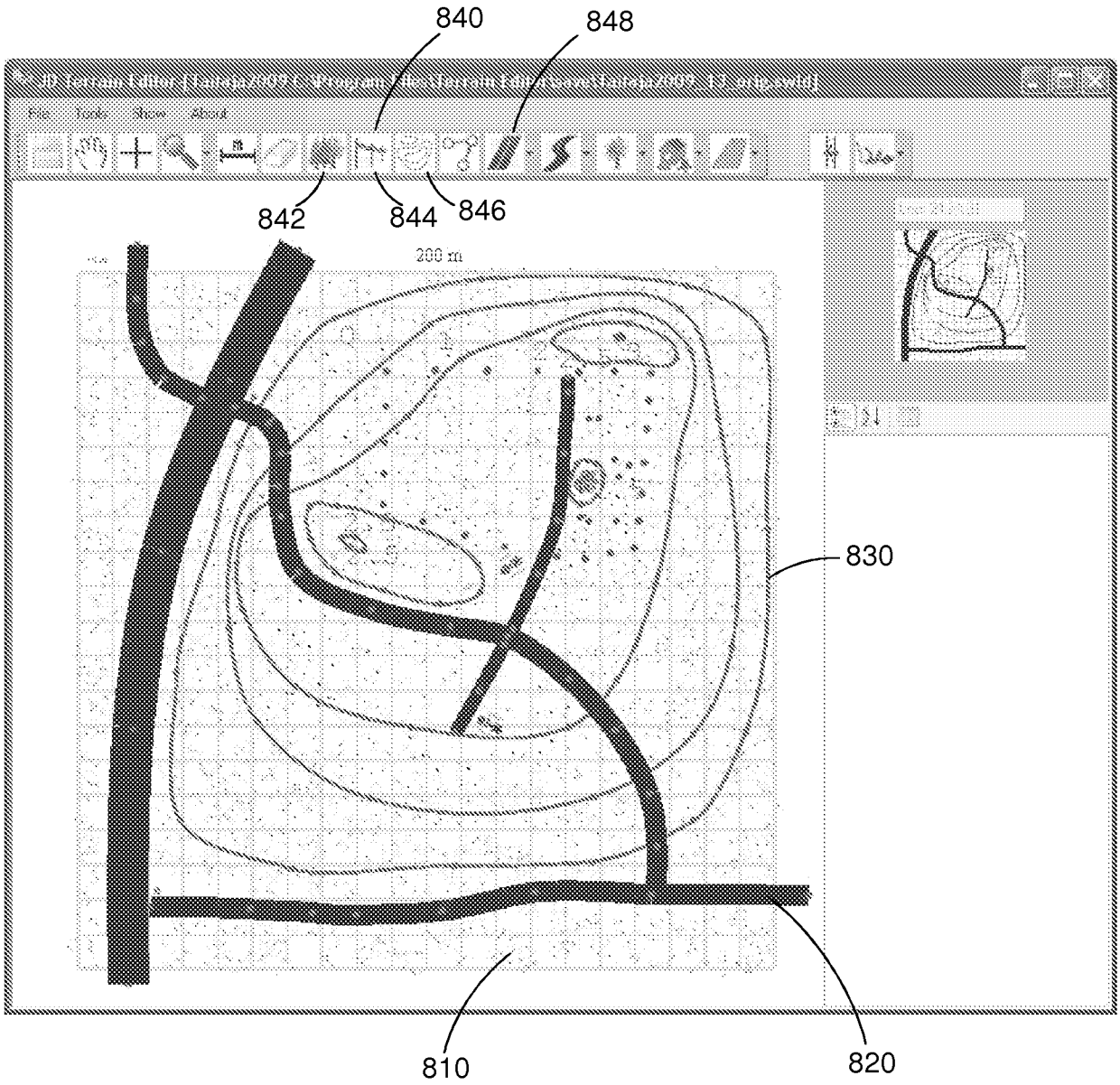


Fig.8

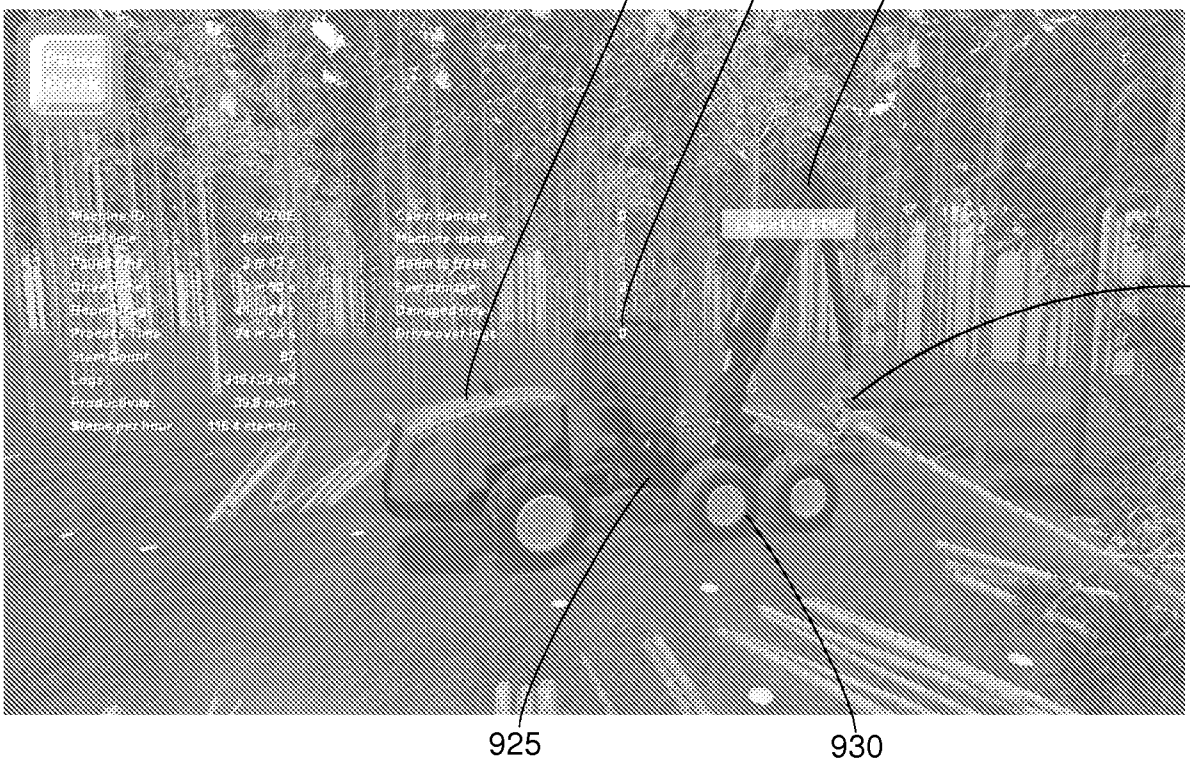


Fig. 9a

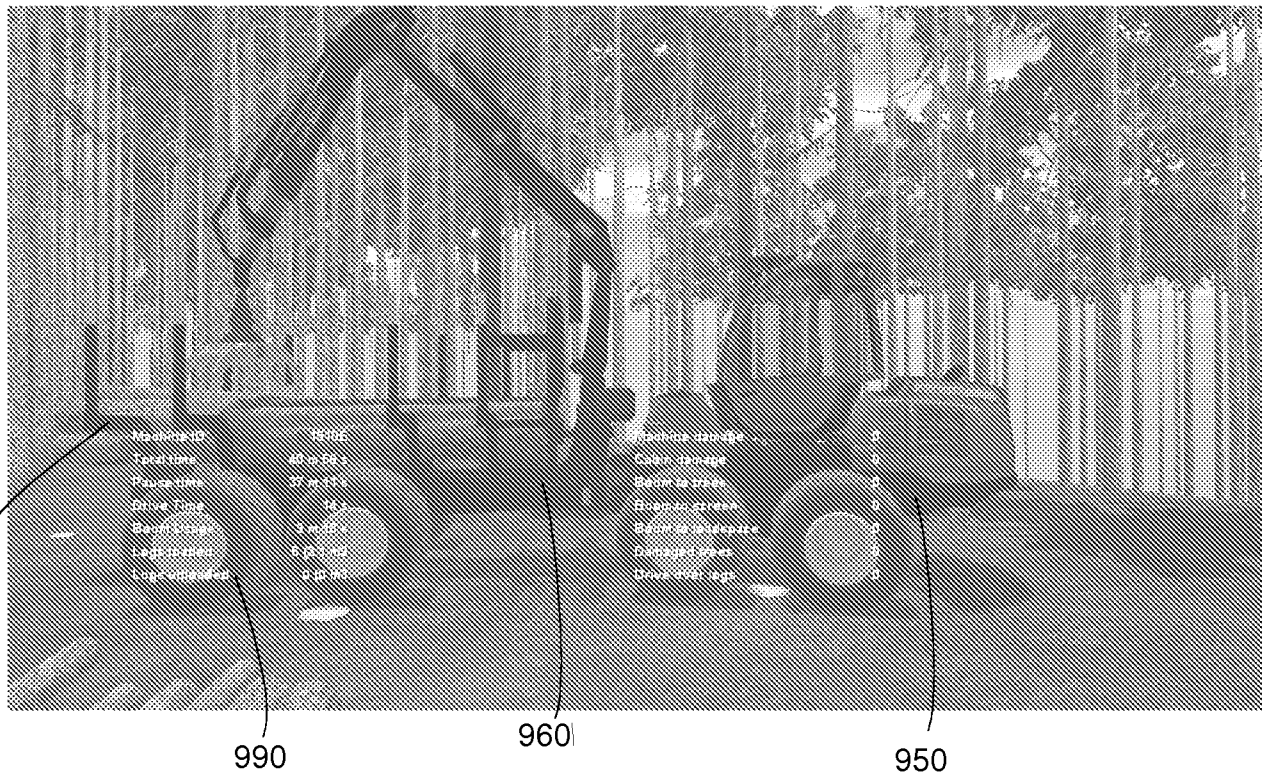
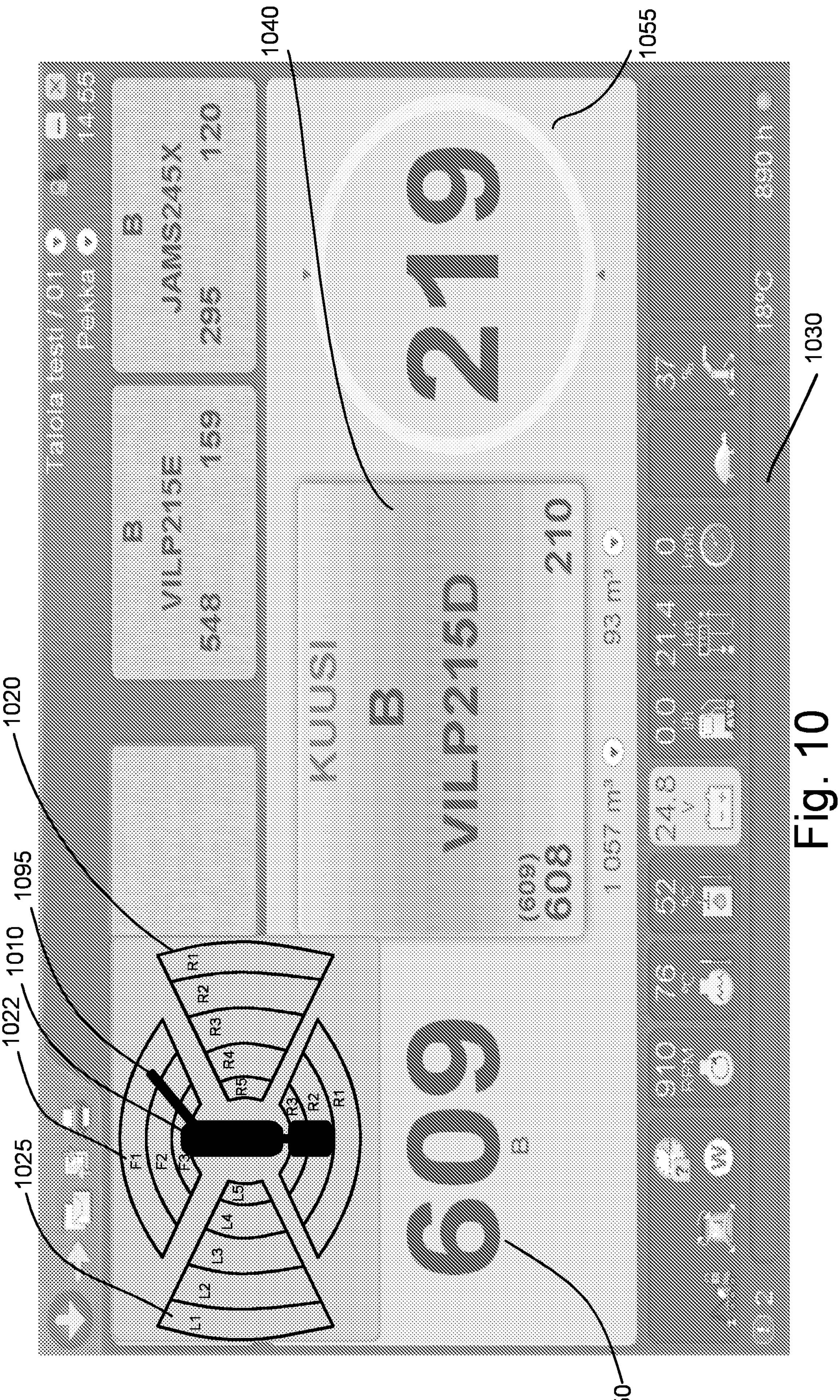


Fig. 9b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1055
1020
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1010
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295
120
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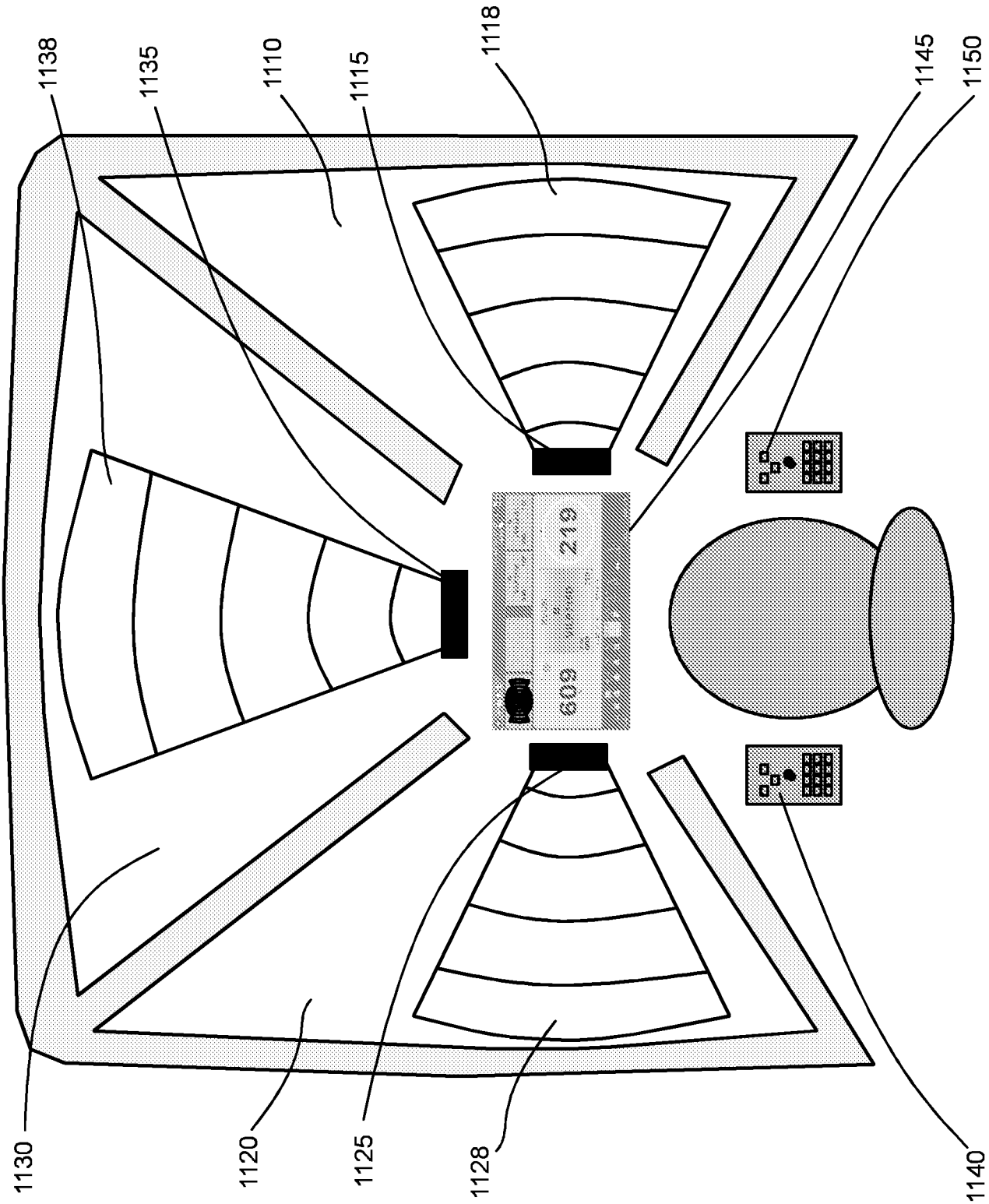
VILP215E
548
159
KUUSI
B
VILP215D
(609)
608
210
1 057 m³
93 m³
219
609
B
F1
F2
F3
R1
R2
R3
R4
R5
L1
L2
L3
L4
L5
910
76
52
24.8
0.0
21.4
0
37
18°C
830 h

Fig. 10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1125
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1140
219
609

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2009/050975

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G07C, G09B, A01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, BIOSIS, BOCA, COMPDX, EMBASE, INSPEC, MEDLINE, NPL, TDB, XP3GPP, XPAIP, XPESP, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPMISC, XPOAC, XPRD, XPTK, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2414010 A (J C BAMFORD EXCAVATORS LIMITED) 16 November 2005 (16.11.2005) abstract; figures 4 - 5; page 6, paragraph 4 - page 8, paragraph 1; page 9, paragraph 3	1 - 19, 22 - 28
Y	ibid.	20 - 21
X	US 2009219199 A1 (BORCHERT JOANNE CHARLOTTE et al.) 03 September 2009 (03.09.2009) abstract; figures 3 - 4; paragraphs [0018], [0024] - [0029], [0035]	1 - 19, 22 - 28
Y	ibid.	20 - 21
X	US 5751576 A (MONSON ROBERT J) 12 May 1998 (12.05.1998) abstract; figures 1 - 2, 8; column 7, line 44 - column 10, line 46; claim 1	1 - 19, 22 - 28
Y	ibid.	20 - 21

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 September 2010 (21.09.2010)	23 September 2010 (23.09.2010)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2009/050975

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008180523 A1 (STRATTON KENNETH L et al.) 31 July 2008 (31.07.2008) abstract; figures 3 - 4; paragraphs [0014], [0017] - [0018], [0027] - [0034], [0043] - [0049]	1 - 22, 24, 26 - 27
Y	ibid.	23, 25, 28
X	US 5404661 A (SAHM WILLIAM C et al.) 11 April 1995 (11.04.1995) abstract; figures 12a, 12f - 12g, 13 - 16; column 7, lines 3 - 34; column 8, lines 7 - 33; column 13, lines 50 - 64; column 14, line 40 - column 15, line 34; column 16, line 1 - column 18, line 43	1 - 19, 22, 24, 26 - 27
Y	ibid.	20 - 21, 23, 25, 28
X	US 2005027420 A1 (FUJISHIMA KAZUO et al.) 03 February 2005 (03.02.2005) abstract; figures 1, 3, 7 - 11, 17 - 18, 21; paragraphs [0052] - [0053], [0058] - [0059], [0069] - [0079], [0099] - [0107], [0122] - [0124]	1 - 19, 22, 24, 26 - 27
Y	ibid.	20 - 21, 23, 25, 28
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