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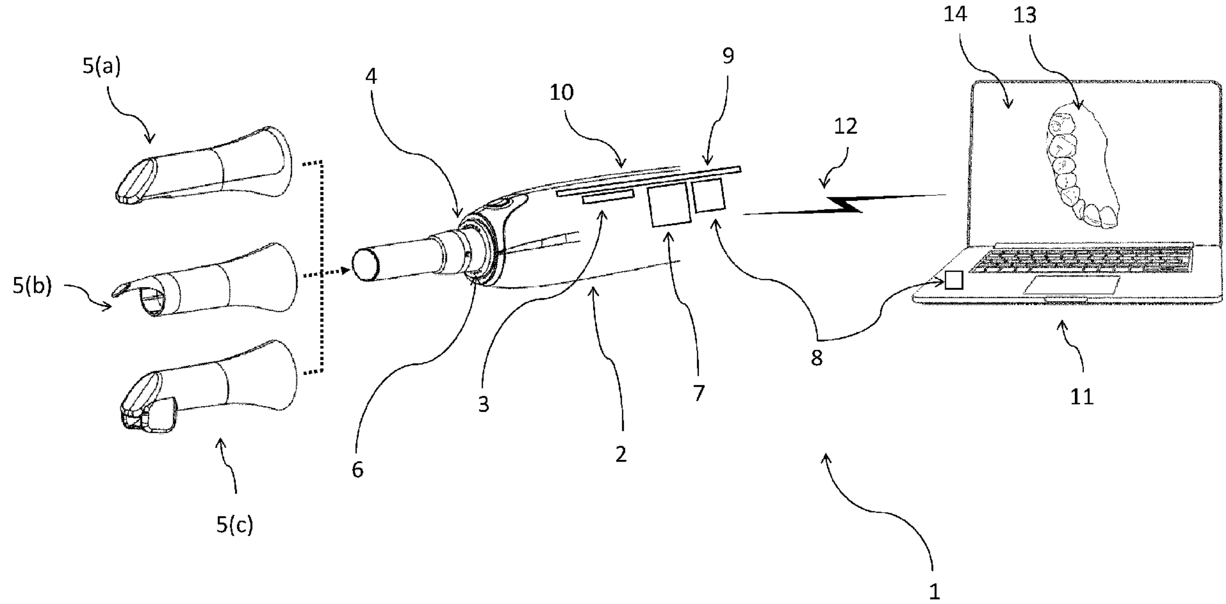

Fig. 1

(57) Abstract: The present disclosure provides a scanning system for scanning an object, comprising: a scanner device comprising: an image sensor for acquiring images; a mounting-interface for detachably mounting at least one of a plurality of types of scanning-tips, wherein each of the plurality of types scanning-tips is configured for providing light to the object in an illumination-mode that differs for each of the plurality of types of scanning-tips.

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Scanner device with replaceable scanning-tips

Field of the invention

The present disclosure relates generally to a scanning system comprising a scanner device with different replaceable scanning-tips. More specifically, the present disclosure relates to how the scanner device operates with the different replaceable scanning tips. Most specifically, the present disclosure relates to scanner devices for intra-oral scanning and/or intra-ear scanning.

Background

Scanner devices with replaceable scanning-tips are known in the field of scanning. For example, in the field of intra-oral scanning, scanning tips with different optical configurations are well-known.

One scanning-tip might for example be configured with one specific field-of-view and another scanning-tip might for example be configured with different field-of-view. This allows not only for changing the field-of-view, but because the field-of-view is related to the physical dimension of the scanning-tip, it also allows for the size of the scanning-tip to be changed. In this way, the one scanning tip may be used for intra-orally scanning of adults, and the other scanning-tip may be used for intra-orally scanning of children.

Also, one scanning tip might for example be configured to move an optical component, such as a mirror, at one frequency, and another scanning tip might for example be configured to move an identical optical component, such as an identical mirror, at another frequency. This may for example allow for scanning at different scanning rates dependent on the scanning-tip being used.

All in all, it is well-known in the field of scanning that scanning-tips can be replaced such that the scanning-operation is adapted to a specific scanning-situation and/or such that the scanning-operation is adapted to a specific object to be scanned.

However, the flexibility of change in scanning-operation is limited to the hardware or to the change in the operation of the hardware responsible for the scanning.

Further, the scanning-operation might not be the only operation that the operator of the scanner device would like to change.

A more flexible scanner device is therefore desired in the field of scanning.

Summary

One objective of the present disclosure is to provide a more flexible scanner device.

The present disclosure provides in a first aspect a scanning system for scanning an object, comprising: a scanner device comprising: an image sensor for acquiring images; a mounting-interface for detachably mounting at least one of a plurality of types of scanning-tips, wherein each of the plurality of types scanning-tips is configured for providing light to the object in an illumination-mode that differs for each of the plurality of types of scanning-tips; and a recognition component for recognizing the type of scanning-tip mounted to the mounting-interface. Further, the scanner device may comprise a processor configured for processing the images acquired by the image sensor into processed data. Even further, the scanner device may comprise a controller configured for controlling the operation of the processor according to the type of the scanning-tip recognized by the recognition component.

The scanner device as here disclosed may advantageously adapt the operation of the processor to a specific scanning-situation or to a specific scanning-object. This allows for example to operate the scanner device in the same manner for two different scanning-situations or for two different scanning-objects but processing the acquired images differently dependent on the scanning-situation or the scanning-object. For example, the scanning tip may be operated in the same manner for two different scanning-situation of to the scanning-object. In this manner, based on the type of scanning-tip being used, an operator may get different results of the processed images.

Furthermore, the disclosed scanner device may also allow for example to operate the scanner in different manners for two different scanning-situations or for two different scanning-objects and processing the acquired images differently dependent on the scanning-situation or the scanning-object. For example, the scanning tip may be operated differently for two different scanning-situations or for two different scanning-objects. In this manner, based on the type of scanning-tip being used based on the scanning-operation of the scanning-tip, an operator may also get different results of the processed images.

Accordingly, the present disclosure provides a much more flexible scanner device than typical scanner devices. To understand this advantage better, examples of how typical scanners work is described below.

The processor in typical scanner devices, as configured to process images acquired by the scanner device, typically performs a well-defined task regardless of the scanning-situation and/or regardless of the scanning-object being scanned. For example, a fixed or well-defined processing-task may be in:

- a confocal scanner, i.e. a scanner that at least comprises a processor configured to derive a depth-coordinate based on isolated analysis of single image-points on an image-sensor, for example by isolated analyzing the intensity of single image-points on the image-sensor and determining when the single image-point is maximum and therefore in-focus;
- a triangulation scanner, i.e. a scanner that at least comprises a processor configured to derive a depth coordinate based on triangularization of one or more light stripes on an image-sensor, for example by analyzing the position of a light stripe in relation to a known position on the image sensor; and/or
- a structured light projection focus-scanner, i.e. a scanner that at least comprises a processor configured to derive a depth-coordinate based on comparative analysis of a plurality of image-points on an image-sensor, for example by analyzing the correlation of the plurality of points with a reference on the image-sensor and for example determining when the correlation of the plurality of image-points is maximum and therefore in-focus.

One of the different processing-tasks, as described above, may for example be performed by a field-programmable-gate-array (FPGA) processor residing in the given scanner device. The processor may then perform the given task because the processor is instructed thereto by a pre-defined script that may run on the scanner device. Typical scanners are therefore not very flexible when it comes to the processing of the images.

The inventors of the scanner device as here disclosed have realized that by having a controller configured for controlling the operation of the processor according to the type of the scanning-tip recognized by the recognition component, the scanner device does not need to have a fixed processing-task, for example as pre-defined on the scanner-device, and the scanner device does not need to run different scripts as defined or re-defined by an operator.

By the presently disclosed scanner, the processing tasks or mode of the acquired images as performed by the processor is defined in an adaptable manner and defined by the controller as defined by the recognition-element once a specific scanning-tip is mounted to the scanner device.

A technical effect of this adaption is that the processing task or mode of the processor, in addition to being adapted to the given scanning-situation and/or scanning-object, is efficiently controlled. For example, by letting the controller control the process of the processor is much faster than manually selecting or instructing the processor to process the acquired images.

All in all, the present disclosure provides a scanner device which efficiently adapts both the scanner and the scanner-output, i.e. the processed images, to a given scanning-situation and/or scanning object.

In a second aspect, the present disclosure provides a computer-implemented method for generating a 3D-representation of an oral cavity displayed in a graphical user-interface on a screen, comprising the steps of:

- displaying, in the graphical user-interface, a plurality of options for scanning, such that a user is instructed, in the user-interface, to select one of said options for scanning;
- receiving, by the user, one or more of said options for scanning;
- displaying, in the graphical user-interface, and based on the one option for scanning as received, first mounting-instructions for the user to mount a first scanning-tip to a scanner device;
- receiving first information from the scanner related to the first scanning-tip when the first scanning-tip is mounted to the scanner device;

- displaying, in the graphical user-interface, and based on the first information from the scanner, a first scanning instruction and/or a first scanning indication for the user to scan with the scanner device having mounted the first scanning-tip,
- receiving first scan data by the scanner device with the first scanning-tip, wherefrom a first part of the 3D-representation is generated;
- displaying, in the graphical user-interface, and based on the first scan data as received, second mounting instructions to replace the first scanning-tip with a second scanning-tip;
- receiving second information from the scanner device related to the second scanning-tip when the second scanning tip is mounted to the scanner device;
- displaying, in the graphical user-interface, and based on the second information from the scanner device, a second scanning instruction and/or a second scanning indication for the user to scan with the scanner device having the second scanning-tip; and
- receiving second scan data by the scanner device with the second scanning-tip, wherefrom a second part of the 3D-representation is generated.

The 3D-representation as generated using the above disclosed method, i.e. a final 3D representation made of at least the first part of the 3D-representation and the second part of the 3D-representation, depends on the interaction between the user and the user-interface. Further, an advantage of the above disclosed method, as may be performed by a processor on for example a computer, is that the 3D-representation is generated only when the user does what he or she is instructed to via the user-interface. For example, the first scan data is only received by the processor when the user mounts the first scanning-tip as displayed in the user-interface, and the second data is only received by the processor when the user mounts the second scanning-tip as displayed in the user-interface. Accordingly, the herein disclosed method provides at least two steps that change the way that the 3D-representation is made. Further, because the process is only able to continue to the steps of receiving data when the proper scanning-tip is mounted, the method can only be carried out when the user correctly mounts the correct scanning-tip. Thus, if the user by error does not correctly mount the scanning-tip as instructed, and/or if the user does not mount the correct scanning-tip as instructed, then the process is not carried out. Thus, the user is also prevented from carrying out a process that is not wanted. Accordingly, the interaction between the user-interface and the physical world changes the process of generating the 3D-representation.

In one embodiment of the second aspect of the invention, the first and second scanning-tips may be two of a plurality of types of scanning-tips, wherein each of the two types scanning-tips is configured for providing light to the object in an illumination-mode that differs for each of the two types of scanning-tips.

In some embodiments, the two aspects may be combined. For example, the scanning system according to the first aspect may include a processor to perform the computer-implemented method according to the second aspect.

Accordingly, in another embodiment of the second aspect, the step of receiving the first information from the scanner device related to the first scanning-tip and/or the step of receiving the second information from the scanner device related to the second scanning-tip is provided from a recognition component in the scanner device, according to the second aspect of the invention, that recognizes the type of scanning-tip when mounted to the scanner device.

Brief description of the drawings

The above and/or additional objects, features and advantages of the present disclosure, will be further described by the following illustrative and non-limiting detailed description of embodiments of the present disclosure, with reference to the appended drawing(s), wherein:

Fig. 1 shows an example of a scanning system **1** according to the invention.

Fig. 2 shows an example of a processing-mode related to intra-oral scanning mode

Fig. 3 shows an example of a processing-mode related to inner-ear scanning mode

Fig. 4 shows an example of a processing-mode related to intra-oral and infrared scanning mode

Fig. 5 shows an example of a processing-mode related to intra-oral and fluorescent scanning mode

Fig. 6 shows an example of a processing-mode related to intra-oral and reduced field-of-view scanning mode

Fig. 7a shows an example of a processing-mode related to face scanning and enlarged field-of-view scanning mode, and Fig. 7b shows details of a scanning-tip used for face scanning.

Fig. 8 shows an example of processing-mode related to intra-oral scanning mode

Fig. 9 shows an example of a processing-mode related to intra-oral scanning mode

Fig. 10(a-e) shows an example of a user-interface according to the second aspect of the invention.

Detailed description

The controller and the processing-mode(s)

In one embodiment of the scanning system, the controller is further configured for controlling the processor such that when a first type of scanning-tip is mounted and recognized, the processor is controlled to operate in a first processing-mode corresponding to the first type of scanning-tip, and such that when a second type of scanning-tip is mounted and recognized, the processor is controlled to operate in a second processing-mode corresponding to the second type of scanning-tip, wherein the second processing-mode is different from the first processing-mode.

In a first preferred embodiment, when in the first processing mode, the processor processes a first plurality of images acquired with a first illumination-mode to provide the processed data in the form of first data for 3D geometry and first data for texture of the object, wherein the first data for the 3D geometry is based on: a first subset of the first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and/or a first subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and wherein the first data for the texture of the object is based on: a second subset of the first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and/or a second subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode.

In a second preferred embodiment, when in the second processing mode, the processor processes a second plurality of images acquired with a second illumination-mode to provide the processed data in the form of second data for 3D geometry and second data for texture of the object, wherein the second data for the 3D geometry is based on: a first subset of the second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode, and/or a first subset of pixels within said second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode, wherein the second data for the texture of the object is based on: a second subset of the second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode, and/or a second subset of pixels within said second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode.

For example, a first type of scanning-tip may be for scanning using white light, and a second type of scanning-tip may be for scanning using infra-red light. Thus, when in the first processing mode, the processor may process a first plurality of images acquired with a first illumination-mode, for example corresponding to white-light-illumination, to provide the processed data in the form of first data for 3D geometry and first data for texture of the object.

According to the above described first preferred embodiment, then when in the first processing-mode, the processor may process all the first plurality of images, and from these first plurality of images, the processor may process a first subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode. The first subset of pixels may for example be all the green pixels or a selected set of green pixels. Upon processing said green pixels, the first data for the 3D geometry is provided.

Further, according the above described first preferred embodiments, then when in the first processing-mode, the processor may also process all the first plurality of images, and from these first plurality of images, the processor may process a first subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode. The first subset of pixels may for example be a selected set of green, red and blue pixels. Upon processing said green, red and blue pixels, the first data for the texture of the object is provided.

Further, when in the second processing mode, the processor may process a second plurality of images acquired with a second illumination-mode, for example corresponding to infra-red light-illumination, to provide the processed data in the form of second data for 3D geometry and second data for texture of the object.

According to the above described second preferred embodiment, then when in the second processing-mode, the processor may process every second image of the second plurality of images, and from these first plurality of images, the processor may process a first subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the second processing mode. The first subset of pixels may for example be all the green pixels or a selected set of green pixels. Upon processing said green pixels, the second data for the 3D geometry is provided.

Further, according the above described first preferred embodiments, then when in the second processing-mode, the processor may also process images between every second image as processed for the 3D-geometry, and from these images, the processor may process a first subset of pixels within said second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode. The first subset of pixels may for example be a selected set of red pixels. Upon processing said red pixels, the second data for the texture of the object is provided.

As can be seen from the above example, the first processing mode differs from the second processing mode, and vice-versa.

The further elaborate on this, the above example illustrates an embodiment, where the first data for the 3D geometry is based on the first subset of the first plurality of images, and the first subset of pixels within said first plurality of images, and wherein the first data for the texture of the object is based on the second subset of the first plurality of images and the second subset of pixels within said first plurality of images, wherein the first subset of the first plurality of images is identical to the second subset of the first plurality of images, and wherein the first subset of pixels within said first plurality of images is different from the second subset of pixels within said first plurality of images.

Even further, the above example also illustrates an embodiment, where the second data for the 3D geometry is based on the first subset of the second plurality of images, and the first subset of pixels within said second plurality of images, and wherein the second data for the texture of the object is based on the second subset of the second plurality of images and the second subset of pixels within said second plurality of images, wherein the first subset of the second plurality of images is different from the second subset of the second plurality of images, and wherein the first subset of pixels within said second plurality of images is different from the second subset of pixels within said second plurality of images.

On advantage of having the first processing mode that differs from the second in the described manner and according to the herein disclosed scanning system, is that data processing can be reduced to limit the amount of data being sent to processor for generating a 3D-model. By reducing the amount of data to generate a 3D-model, a wireless connection between the scanner device and an external processor to generate the 3D-model may be established in that only a certain amount of data can be transmitted wirelessly. Further, by reducing the amount of data to generate a 3D-model, the 3D-model can be generated faster than if all data is processed in the same manner regardless of the scanning tip.

Other examples of where the first processing mode differs from the second processing mode, and vice-versa, are described by the following embodiments.

In a first embodiment, the first data for the 3D geometry is based on the first subset of the first plurality of images, and the first subset of pixels within said first plurality of images, and wherein the first data for the texture of the object is based on the second subset of the first plurality of images and the second subset of pixels within said first plurality of images, wherein the first subset of the first plurality of images is different from the second subset of the first plurality of images, and wherein the first subset of pixels within said first plurality of images is different from the second subset of pixels within said first plurality of images.

In a second embodiment, the first data for the 3D geometry is based on the first subset of the first plurality of images, and the first subset of pixels within said first plurality of images, and wherein the first data for the texture of the object is based on the second subset of the first plurality of images and the second subset of pixels within said first plurality of images, wherein the first subset of the first plurality of images is different from the second subset of the first plurality of images, and wherein the first subset of pixels within said first plurality of images is identical to the second subset of pixels within said first plurality of images.

In a third embodiment, the first subset of the first plurality of images is every second image of the plurality of images as recorded with non-chromatic light at a plurality of wavelengths, and wherein the second subset of the first plurality of images is the remaining images of the plurality of images recorded with monochromatic light at a first wavelength.

In a fourth embodiment, the first subset of the first plurality of images is every third image of the first plurality of images as recorded with non-chromatic light defined by a plurality of wavelengths, and wherein the second subset of the first plurality of images is the remaining images of the first plurality of images recorded with monochromatic light at a first wavelength and at a second wavelength.

In a fifth embodiment, the second subset of the first plurality of images is a single image as recorded with non-chromatic light defined by a plurality of wavelengths.

In a sixth embodiment, the second data for the 3D geometry is based on the first subset of the second plurality of images, and the first subset of pixels within said second plurality of images, and wherein the second data for the texture of the object is based on the second subset of the second plurality of images and the second subset of pixels within said second plurality of images, wherein the first subset of the second plurality of images is identical to the second subset of the second plurality of images, and wherein the first subset of pixels within said second plurality of images is different from the second subset of pixels within said second plurality of images.

In a seventh embodiment, the second data for the 3D geometry is based on the first subset of the second plurality of images, and the first subset of pixels within said second plurality of images, and wherein the first data for the texture of the object is based on the second subset of the second plurality of images and the second subset of pixels within said second plurality of images, wherein the first subset of the second plurality of images is different from the second subset of the second plurality of images, and wherein the first subset of pixels within said second plurality of images is identical to the second subset of pixels within said second plurality of images.

The above described embodiments all benefit by providing a system where data processing can be reduced to limit the amount of data being sent to processor for generating a 3D-model.

The data for the 3D geometry may be in the form of a point cloud, or data adaptable to form a point cloud. A point cloud typically relates to points in a 3D universe, such as the Euclidian space.

The data for the texture may comprise color data, such as RGB color data, and/or may be in the form of direct color, a compressed format, or an indexed color.

The processor as described herein may be responsible for deriving the data for the 3D geometry and the texture in various ways dependent on the scanning-tip. For example, when using a tip with white-light-illumination, the processor may derive both a point cloud, and for each point in the cloud, a corresponding RGB color. The derivation of the data is clearly based on the images of the scanner device. In some embodiments of the processing-modes, the first processing mode or the second processing mode is such that the data for the 3D geometry and the data for the texture is derived from each single image in a stack of images. In other embodiments, the first processing-mode or the second processing-mode is such that the first data for the 3D geometry and the data for the texture, or the second data for the 3D geometry and the second data for the texture, is derived from a set of images in a stack of images, for example such that at least one image is used for deriving the first data for the 3D model or the second data for the 3D model, and another separate at least one image used for deriving the first data for the texture for the 3D model or the second data for the texture for the 3D model.

In one embodiment, when in the first processing-mode, both the first data for the 3D geometry and the first data for the texture of the object is derived for each of the images among the plurality of images. According to the herein disclosed scanning system where the processing-modes are different, then related to the just described embodiment, the second processing-mode may in one embodiment be such that second data for the 3D geometry and the second data for the texture of the object is derived for a set of images among the plurality of images. However, as previously described, it could also be the other way around. For example, in another embodiment, when in the first processing-mode, both the first data for the 3D geometry and the first data for the texture of the object is derived for a set images among the plurality of images. According to the embodiment where the processing-modes are different, then related to the just described embodiment, the second processing-mode may in one embodiment be such that second data for the 3D geometry and the second data for the texture of the object is derived for each of the images among the plurality of images.

In some embodiments, when in the first processing-mode, the first data for the 3D geometry and the first data for the texture of the object is derived for different images among the plurality of images. Also, in some other embodiments, when in the second processing-mode, the second data for the 3D geometry and the second data for the texture of the object is derived for different images among the plurality of images.

In one embodiment, the first data for the 3D geometry and/or the first data for the texture is derived for every second image among the plurality of images. In another embodiment, the second data for the 3D geometry and/or the second data for the texture is derived for every second image among the plurality of images. For example, every second image among the plurality of images may be acquired with white light-illumination, and the images in-between may be acquired with infra-red light-illumination or fluorescence light-illumination. If using a white light-illumination, the processor may in some embodiments be configured to and/or instructed by the controller to derive the data for the 3D geometry and the data for the texture from the each of the images acquired with the white light-illumination. If using infrared light-illumination, the processor may in some embodiments be configured to and/or instructed by the controller to derive only the data for texture from the each of the images acquired with the infrared light-illumination. If using fluorescence light-illumination, the processor may in some embodiments be configured to and/or instructed by the controller to derive only the data for texture from the each of the images acquired with the fluorescence light-illumination.

In other embodiments, the scanner device further comprises a lens configured to translate back and forth while the first and/or second plurality of images is acquired. This may for example be the case for a confocal scanner device or for a structured light projection focus-scanner. A triangulation scanner may not need such a lens.

In some embodiment, the second data for the texture is derived for a single image among the plurality of images as acquired while translating a lens element back and forth. For example, when the single image is acquired with infrared light-illumination. This may allow for a 2D infrared image to be acquired such that it thereafter may be correlated to a 3D-model as provided for by other 2D-images acquired during the translation of the lens.

In a preferred embodiment, the controller is external to the scanner device. Thus, according to one embodiment of the invention, when the recognition component recognizes the type of scanning-tip mounted to the mounting-interface, then the controller (as configured for controlling the operation of the processor according to the type of the scanning-tip recognized by the recognition component) controls the operation of the processor. This means that in this embodiment, the recognition component may transmit information (for example information of the mounted scanning-tip in the form of an identification number) to the controller as located remote from the scanner device. The scanner device may accordingly be configured to transmit such information to the remotely located controller, for example on an external computer or a cloud service. This transmission may for example be a wired transmission or a wireless transmission. Once the controller receives the information of the mounted scanning-tip, the controller may transmit instructions (dependent on the information of the tip) to the processor, for example located on the scanner device. Thus, the controller and/or external computer may accordingly be configured to transmit such information back to the scanner device. This transmission may also for example be wired transmission or wireless transmission. In most embodiments, the type of transmission (from the scanner device to the controller, and from the controller to the scanner device) is identical. Finally, when the processor receives the instructions, the processor may process the images as instructed and dependent on the information of the tip. One advantage of having the controller external to the scanner device is that the controller can be modified independently of the scanner device, and for example be modified via the internet. Another advantage is that the controller needs not to be present in the scanner device, and therefore the scanner device itself can be made more compact. Further, because a controller produces heat when instructing a processor, the scanner device will also produce less heat hence less power. This may be advantageous when for example the scanner device is configured to operate in a wireless mode and/or powered by a battery.

In another preferred embodiment, the controller is integrated in the scanner device. One advantage of having the controller in the scanner device is that the communication link from the controller to the processor is reduced (for example in comparison to the embodiment just described), meaning that the instructions to the processor can be transmitted efficiently thereto.

The processor(s)

In one embodiment, the processor is integrated in the scanner device. In this embodiment, the processer is then configured for processing the images acquired by the image sensor into processed data in the scanner device. The processor may, based on the images, derive data in the form of data for 3D geometry and data for texture of the object.

The processed data or derived data might not need to be distributed in the spatial domain. For example, the processed data may be partly in the spatial domain, and partly in the temporal domain. Further processing of the processed data may then be applied to convert the processed data to purely spatial domain-data. In one embodiment, the processed data is data 3D geometry, and as here explained, this may be processed data in the spatial domain or the temporal domain, or a mix thereof.

An advantage of integrating the processor in the scanner device is that less data needs to be transmitted by the scanner device itself. Thus, to reduce the load of a wireless module transferring data to an external processing device, it is advantageous to process as much data as possible on the scanner device.

Various processor(s) are known for processing images on hand-held devices, but for rather simple processing, such as to compare intensities or more generally to perform operations such as multiplication and/or addition, a Field-Programmable Gate Array (FPGA) processor is desired. Thus, in a preferred embodiment, the processor comprises an FPGA-processor.

In a most preferred embodiment, the processor is further configured for compressing the processed data. This may also enable that a wireless module in the scanner device receives the processed data in the form of compressed data from the processor and wirelessly transmits the processed data in the form of compressed data. Thus, in some embodiments, an FPGA processor both processes and compresses data.

In one embodiment, the scanner device comprises a wireless module which receives the processed data from the processor and wirelessly transmits the processed data to an external processing device. For the wireless module to receive the processed data from the processor, the processor is configured to transmit the processed data to the wireless module.

In another embodiment, the transmission of data to a wireless module on the scanner device is performed by the processer, preferably a central processing unit (CPU) comprising a reduced instruction set computer (RISC) architecture. For example, to transmit processed data to the wireless module, the processor may be in the form of an Advanced RISC Machines (ARM)-processor such as based on 32 bits or 64 bits instructions.

In other words, in another embodiment, the processor comprises an ARM-processor. An ARM-processor is different from an FPGA processor, and the two types of processors are designed for different tasks. Thus, in most preferred embodiments, the processor comprises both an FPGA-processor and an ARM-processor.

In some embodiments, the processor is located external to the scanner device, for example on an external processing device.

An advantage of having the processor external to the scanner device is that a processor needs not to be in the scanner device itself. Accordingly, this may reduce the weight and size of the scanner device.

In other embodiments, the scanning system further comprises a processor configured to generate a 3D model of the object, wherein the 3D model is generated based on the processed data and according to the type of the scanning-tip recognized by the recognition component and wherein the 3D model is generated based on the first data for the 3D geometry, but wherein the 3D model is not generated based on the second data for the 3D geometry, or wherein the 3D model is generated based on the second data for the 3D geometry, but wherein the 3D model is not generated based on the first data for the 3D geometry.

Such a processor is preferably located on an external processing device. However, in some embodiments also be located on the scanner device.

In one embodiment, when the 3D model is not generated based on the second data for the 3D geometry, then the second data for the 3D geometry is compared to the first data for the 3D geometry, whereby the second data for texture of the object is matched to the 3D-model.

In another embodiment, when the 3D model is not generated based on the first data for the 3D geometry, then the first data for the 3D geometry is compared to the second data for the 3D geometry, whereby the first data for texture of the object is matched to the 3D-model.

By only comparing the first or second data for the 3D geometry to the second or firs data for geometry and not generating the 3D-model, data processing is optimized both in by increasing processing speed and reducing data transfer.

Scanning-tips and recognition element

According to the invention, each of the plurality of types scanning-tips is configured for providing light to the object in an illumination-mode that differs from each of the plurality of types of scanning-tips.

Providing of light to the object may in one embodiment be via an optical element, for example via a mirror, located in the scanning-tip, such that the light may be generated in the scanner device, and directed to the scanning-tip and re-directed via the mirror to the object. The light generated in the scanner device may be generated from a light source residing inside the scanner device, and external to the to the scanning-tip.

Providing of light to the object may in another embodiment be directly from the scanning-tip, such that the light may be generated in the scanning-tip. The light generated in the scanning-tip may be generated from a light source residing inside the scanning-tip and/or on the scanning-tip. In some embodiments, the light source inside the scanning-tip and/or on the scanning-tip may be a plurality of light sources, such as a plurality of light emitting diodes (LEDs).

Further, according to the invention, the scanner device comprises a recognition component for recognizing the type of scanning-tip mounted to the mounting-interface.

In one embodiment, the recognition element comprises a memory-reader configured to read recognition-data from an integrated memory on each of the plurality of types scanning-tips.

In another embodiment, the type of scanning-tip, as recognized by the recognition component, is in the form of recognition-data, and wherein the scanner device is configured to transmit the recognition-data to the controller.

Illumination-mode for scanning tips

In one embodiment, the illumination-mode for one type of scanning-tip is defined by the wavelength of the light. For example, one illumination-mode may be defined as white light-illumination, where white light is referred to a light in the wavelength-domain between 400 nm to 700 nm. Another illumination-mode may be defined as infrared light-illumination, for example with a wavelength around 850 nm. A third illumination-mode may be defined as fluorescent light-illumination, where blue light around 415-405 nm or UV light may be used to excite a fluorescence response from the illuminated teeth.

In another embodiment, the illumination-mode for one type of scanning tip is defined by the intensity of the light.

In yet another embodiment, the illumination-mode for one type of scanning-tip is defined by the field-of-view of the light.

In some embodiments, the illumination-mode for one type of scanning-tip is defined by a pattern of the light.

In some embodiments, the illumination-mode for one type of scanning-tip is defined by different wavelengths of the light, whereby one type of scanning-tip switches between the different wavelengths of the light. For example, a first type of scanning tip may be configured for providing both white light and infrared light to the object, and a second type of scanning tip may be configured for providing both white light and blue light/UV light to excite a fluorescence response from the illuminated object. One advantage of such scanning tips in combination with the herein disclosed scanning system is that the 3D model needs not to be generated based on 3D geometry as provided by such tips. The 3D model may have already been generated based on data provided by a tip that does not switch between different wavelengths of light.

User-interface

In one embodiment of the second aspect, the step of receiving, by the user, one or more of said options for scanning is provided by the user clicking on the one or more of said options in the user-interface.

In a second embodiment of the second aspect, the one of said options for scanning is related to edentulous scanning. By selecting this option, the method may according to the second aspect of the invention, instruct the user to firstly mount a first scanning-tip that is configured to scan with a large field-of-view, whereby the scanning tip is adapted to cover a substantial part of the entire jaw (e.g. 50% of the jaw). Using such a scanning-tip provides that 3D-registration relies on the overall jaw structure. The method according to the second aspect of the invention may thereafter instruct the user to mount a second scanning-tip that is configured to scan with small field-of-view, such as a conventional intraoral scanning-tip. Using such a scanning-tip provides that 3D-registration relies only on a part of the overall structure.

Typically, when scanning an edentulous patient with a conventional scanning-tip, the 3D-registration (which relies only on the part of the overall structure) may be compromised due to unbound gingiva that shifts around during scanning. However, by using the first-scanning-tip, and then changing to the second scanning-tip, 3D-registration of data related to the second scanning-tip may be improved because the first scanning-tip may provide a reference for the 3D-registration of data related to the second scanning-tip. Further, by using the first-scanning-tip, and then changing to the second scanning-tip, as described above and according to the second aspect of the invention, processing time is also reduced because registration errors need not to be corrected.

In some embodiments, the first scanning-tip is configured for scanning with a larger field-of-view in comparison to the second scanning-tip, whereby the first part of the 3D-representation is used as a reference model for the second part of the 3D-representation being matched to the reference model. As just explained above, such embodiments improve 3D-registration.

As previously explained, the step of receiving the first information from the scanner device related to the first scanning-tip and/or the step of receiving the second information from the scanner device related to the second scanning-tip is provided from a recognition component in the scanner device that recognizes the type of scanning-tip when mounted to the scanner device.

Additionally, and/or alternatively, the step of receiving the first information from the scanner device related to the first scanning-tip is provided from visual recognition of at least a part of the first scanning-tip in the field of view of the first scanning-tip and/or the step of receiving the second information from the scanner device related to the second scanning-tip is provided from visual recognition of at least a part of the second scanning-tip in the field-of-view of the second scanning-tip.

In a preferred embodiment of the second aspect of the invention, the step of displaying instructions to replace the first scanning-tip with a second scanning-tip is based on confirmation-input from a user, wherein the confirmation-input comprise information confirming that the first part of the 3D-representation as generated is sufficient. For example, the user may click on a button in the user-interface. The button may comprise a text that indicates that the user has determined that the 3D-representation is sufficient. The button may for example also indicate that the user is now ready to proceed to the next procedure in the process, and therefore press a “next” button. Once the input is provided, the user is guided to the next step of replacing the first scanning-tip with the second scanning-tip. The herein disclosed confirmation-input from the user changes the process of providing the 3D-representation, at least by the user providing input to the computer-implemented method such that it can determine in which step the method is, and such that the computer-implemented can continue to the next step.

In a more preferred embodiment of the second aspect of the invention, the first part of the 3D-representation, as confirmed sufficient, is collected over time from: the user, and/or a plurality of different users, thereby forming historical 3D-representations as confirmed sufficient, whereby the step of displaying the instructions to replace the first scanning-tip with a second scanning-tip is automatized and based on the historical 3D-representations as confirmed sufficient. By automizing the process as here described, the process is optimized, especially such that the process of generating the final 3D-representation is reduced in time and made more reliable.

In a most preferred embodiment of the second aspect of the invention, the historical 3D-represenations as confirmed sufficient is used as input for an algorithm configured to determine when the 3D-representation as generated is sufficient, and wherein the algorithm is based on averaging the historical 3D-representations, and/or wherein the algorithm is based on machine learning and/or artificial intelligence.

Example 1 – A scanning system and operation-modes thereof

Fig. 1 shows an example of a scanning system **1** according to the invention. **Fig. 1** shows particularly a scanning system **1** for scanning an object. The object to be scanned is not shown. The scanning system comprises firstly a scanner device **2**. The scanner device **2** comprises: an image sensor **3** for acquiring images; a mounting-interface **4** for detachably mounting at least one of a plurality of types of scanning-tips, **5a, 5b, 5c**, wherein each **(5a or 5b or 5c)** of the plurality of types scanning-tips, **5a, 5b, 5c,** is configured for providing light to the object in an illumination-mode that differs from each of the plurality of types of scanning-tips, **5a, 5b, 5c**. The scanner device further comprises a recognition-component **6** for recognizing the type of scanning-tip, **5a or 5b or 5c**, mounted to the mounting-interface **4**. The scanning system **1** secondly comprises a processor **7** configured for processing the images acquired by the image sensor into processed data. The scanning system **1** thirdly comprises a controller **8** configured for controlling the operation of the processor **7** according to the type of the scanning-tip, **5a or 5b or 5c**, recognized by the recognition component **6**.

The controller **8** may be located either in the scanner device **2,** such as inside a scanner housing **10** of the scanner device **2** or external to the scanner device **2**, such as located on an external processing device **11**, here shown as a lab top **11**.

Alternatively, the controller **8** may be located in both the scanner device **2** and external to the scanner device **2**. For example, a first part of the controller **8** is located in the scanner housing **10** and a second part of the controller **8** is located in the lab top **11**.

When the controller **8** is located in the scanner device **2**, the controller **8** communicates with the processor **7** in the scanner device **(2)** via a printed circuit board (PCB) **9**. The PCB **9** transmits data and control-instructions back and forth between the controller **8** and the processor **7**.

When the controller is located external to the scanner device **2**, the external processing device **11** communicates with processor **7** in the scanner device via at least the communication module **12**. The PCB **9** might also be involved in the communication between the scanner device **2**, i.e. the processor **7** and the external processing device **11**, i.e. the controller **8**. The communication module **12** may for example be a wired communication module **12**, for example comprising a USB cable or an Ethernet cable, configured to transmit data and control-instructions back and forth between the scanner device **2** and the external processing device **11**. Alternatively, the communication module **12** may for example be a wireless communication module **12** configured to wirelessly transmit data and control-instructions back and forth between the scanner device **2** and the external processing device **11**.

In this example, the processor **7** is integrated in the scanner device **2**. However, also in this example, the controller **8** is located only external to the scanner device **2**.

The controller **8** is further configured for controlling the processor **7** such that when a first type of scanning-tip is mounted and recognized, the processor **7** is controlled to operate in a first processing-mode corresponding to the first type of scanning-tip, for example **5(a)**.

This works in the following way. The first type of scanning tip **5(a)** is for intra-orally scanning of teeth using white light, the white light being emitted by a white light source residing in the scanner device **2**. The first type of scanning tip **5(a)** comprises a mirror located at the distal end of the scanning tip **5(a)** with a reflective surface inside the scanning tip such that when the mirror receives light from the white light source, the scanning tip **5(a)** provides light to the object in a first illumination-mode. By mounting the first type of scanning tip **5(a)** to the scanner device **2**, the recognition-component **6** comprises a memory-reader configured to read recognition-data from an integrated memory on the first type scanning-tips **5(a)** such that the recognition-component **6** at least reads which type of scanning tip is mounted to the scanner device **2**. The type of scanning tip, here 5**(a)** as recognized by the recognition-component **6**, is in the form of recognition-data. This recognition-data is transmitted to the external processing device **11** via a wireless module **12.** The controller **8** now receives the recognition-data. Based on that input, i.e. the recognition-data, the controller **8** transmits a first set of control-instructions to the scanner device **2**, more specifically to the processor **7** via the wireless module **12**. Thereby, the processor **7** is instructed to operate in a first processing-mode corresponding to the first type of scanning-tip **5(a)**. When in the first processing mode, the processor **7** processes a first plurality of images acquired with the first illumination-mode, i.e. with the white light, to provide the processed data in the form of first data for 3D geometry and first data for texture of the object. The data for the 3D geometry is related to 3D positions, i.e. points in space, not necessarily in the form of spatial coordinates, but at least transformable thereto. The data for the texture of the object is related to the color of the surface of the object. The processed data is then transmitted to the external processing device **11** via the wireless module **12**. The processing device comprises a processor configured to generate a 3D-model **13** of the object, wherein the 3D-model **13** is generated based on the processed data regardless of the type of the scanning-tip recognized by the recognition component **6**. The 3D-model **13** is finally displayed on a display **14** of the external processing device **11**, here shown on the screen **14** of the lab top **11**.

The controller **8** is even further configured for controlling the processor **7** such that when a second type of scanning-tip is mounted and recognized, the processor **7** is controlled to operate in a second processing-mode corresponding to the second type of scanning-tip, for example **5(b)** or **5(c)**.

This works in the following way. First, the first type of scanning-tip **5(a)** is replaced by the second type of scanning-tip, in this example chosen to be **5(c)**. This is performed by un-mounting the first type of scanning-tip **5(a)** and then mounting the second type of scanning-tip **5(c)**.

The second type of scanning tip **5(c)** is for intra-orally scanning of teeth using infrared light, the red light being emitted by a plurality of infrared light sources residing in the distal end of the scanning tip **5(c)** such that the scanning tip **5(c)** provides light to the object in a second illumination-mode, the second illumination mode being different from the first illumination-mode. By mounting the second type of scanning tip **5(c)** to the scanner device **2**, the recognition-component **6** comprises a memory-reader configured to read recognition-data from an integrated memory on the second type scanning-tips **5(c)** such that the recognition-component **6** at least reads which type of scanning tip is mounted to the scanner device **2**. The type of scanning tip, here **5(c)**, as recognized by the recognition-component **6**, is in the form of recognition-data. This recognition-data is transmitted to the external processing device **11** via a wireless module **12.** The controller **8** now receives the recognition-data. Based on that input, i.e. the recognition-data, the controller **8** transmits a second set of control-instructions to the scanner device **2**, more specifically to the processor **7** via the wireless module **12**. Thereby, the processor **7** is instructed to operate in a second processing-mode corresponding to the second type of scanning-tip **5(c)**. When in the second processing mode, the processor **7** processes a second plurality of images acquired with the second illumination-mode, i.e. with the infrared light, to provide the processed data in the form of second data for 3D geometry and second data for texture of the object. The second processing-mode is different from the first processing-mode. The data for the 3D geometry is related to 3D positions, i.e. points in space, not necessarily in the form of spatial coordinates, but at least transformable thereto. The data for the texture of the object is related to the color of the internal structure of the object. The processed data is then transmitted to the external processing device **11** via the wireless module **12**. The processing device comprises a processor configured to generate a 3D-model **13** of the object, wherein the 3D-model **13** is generated based on the processed data and here based on the type of the scanning-tip recognized by the recognition component **6**. This means that because the second type of scanning-tip **5(c)** is recognized and due to this tip emitting infrared light configured to record internal structures, the 3D-model-generation in the external processing device **11** updates the 3D-model **13**, as generated using the white light, with internal structures of the tooth.

The updated 3D-model **13** is finally displayed on a display **14** of the external processing device **11**, here shown on the screen **14** of the lab top **11**.

<u>Example 2 – Processing-mode in intra-oral scanning mode</u>

In this example, the scanning system **1** is configured for performing intra-oral scanning of at least a portion of a tooth.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a first processing-mode corresponding to scanning intra-orally using a scanning-tip **(5a)** therefor.

This first processing-mode is initiated by mounting the intra-oral tip **5(a)** with a mirror in the distal end that covers the entire optical field-of-view and directs light from the scanner device **2** towards the object to be scanned. The intra-oral tip **5(a)** is shown mounted in **Fig. 2**. This tip is configured for being inserted into the mouth of a patient.

In this example, the processor **7** processes images **15** acquired by the image sensor **3** into processed data **16** while a focus lens is adjusted. The focus lens adjustment is confined to a specific span length, where the focus lens is moved back a forth while recording a plurality of 2D-images **15** of a projected pattern on the object. The processed data **16** is extracted by processing the plurality of 2D images **15**.

When the scanning tip **5(a)** is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip which is stored on an internal memory of the scanning tip **5(a)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images **15** recorded with a white-light illumination pattern on the object. The white light enables that from each 2D-image, both data for 3D geometry and data for texture can be derived. In other words, the processed data **16** is in the form of data for 3D geometry and in the form of data for texture.

Accordingly, the processor **7** on the scanner device **2** processes a subset of the plurality of 2D-images **15** to construct a combined depth-frame and color-frame called a sub-scan. In this example, the processed data **16** from the processor **7** is thus dependent on the processing-mode.

The processed data **16** of a sub-scan is sent as a data package to a scanning application on the externally connected computer **11** responsible for generating the 3D-model **13**.

The primary task of the scanning application is to process individual patches of data packages and reconstruct them to a complete or global scan. That task can be broken down into two primary routines:

Registration: The location of the sub-scan is located in relation to the global scan.

Stitching: The sub-scan is fused into the global scan as registered above.

From the scanning-tip identification-number **17** being recognized, the processor **7** may perform a post-treatment of the processed data before transmitting it. For example, the processed data **16**, or part of it, may be mirrored by the processor **7** prior to being transmitted. Hereafter, the registration and the stitching can be performed on the external processing device **11**. Alternatively, the processed data may be mirrored on the external processing device **11**.

Example 3 – Processing-mode in ear scanning mode

In this example, the scanning system **1** is configured for performing in-ear scanning of at least a portion of an ear. Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a second processing-mode corresponding to scanning in-ear using a scanning-tip **5(b)** therefor.

This second processing-mode is initiated by mounting the ear-tip **5(b)**. This scanning tip **5(b)** is open and forward-looking with a small mirror placed on an extended arm with a small mirror in the distal end that covers only partly the optical field-of-view and directs a portion of the light from the scanner device **2** towards the object to be scanned. The in-ear tip **5(b)** is shown mounted in **Fig. 3**. This scanning tip **5(b)** is configured for being inserted into the ear of a patient.

In this example, the processor **7** processes images **15** acquired by the image sensor **3** into processed data **16** while a focus lens is adjusted. The focus lens adjustment is confined to a specific span length, where the focus lens is moved back a forth while recording a plurality of 2D-images **15** of a projected pattern on the object. The processed data **16** is extracted by processing the plurality of 2D images **15**.

When the scanning tip **5(b)** is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip **5(b)** which is stored on an internal memory of the scanning tip **5(b)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images **15** recorded with a white-light illumination pattern on the object. The white light enables that from each 2D-image, both data for 3D geometry and data for texture can be derived. In other words, the processed data **16** is in the form of data for 3D geometry and in the form of data for texture.

Accordingly, the processor **7** on the scanner device **2** processes a subset of the plurality of 2D-images **15** to construct a combined depth-frame and color-frame called a sub-scan. In this example, the processed data **16** from the processor **7** is thus dependent on the processing-mode.

The processed data **16** of a sub-scan may be sent as a data package to a scanning application on the externally connected computer **11** responsible for generating the 3D-model **13**.

The primary task of the scanning application is to process individual patches of data packages and reconstruct them to a complete or global scan. That task can be broken down into two primary routines:

Registration: The location of the sub-scan is located in relation to the global scan.

Stitching: The sub-scan is fused into the global scan as registered above.

From the scanning-tip identification-number **17** being recognized, the processor **7** may perform a post-processing of the processed data **16**. In this manner, post-processed data **18** is obtained. For example, the post-processed data **18**, or part of it **18(a)**, may be mirrored by the processor **7** prior to being processed. **Fig. 3** shows how part of the post-processed data **18(a)** is partly mirrored, and that noise **18(b)** present in the post-processed data **18** is removed in the processed data **16**. In this case, the processor **7** operates differently from the example described in **Example 2**, and the controller **8** is configured for controlling the operation of the processor **7** according to the type of the scanning-tip (**5a, 5b or 5c**) recognized by the recognition component **6.** Hereafter, the registration and the stitching can be performed on the external processing device **11**. Alternatively, the processed data may be mirrored or partly mirrored on the external processing device **11**.

Regardless of where the processing and/or post-processing takes place, the processed data **16** is processed dependent on the specific scanning-tip. In other words, a tip-specific data-mask may be applied in the post-processing for reflecting and correcting a portion of the processed data **16**. More specifically, the scanning-tip identification-number **17** may be associated with a specific reflection-matrix to be applied by the processor **7** and/or the scanning application as a data post-processing mask when the tip **5(b)** is recognized on the scanner device **2**.

<u>Example 4 – Processing-mode in infrared transillumination scanning mode</u>

In this example, the scanning system **1** is configured for performing intra-oral scanning of at least a portion of a tooth using at least infrared light.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a second processing-mode corresponding to scanning intra-orally with at least infrared light using a scanning-tip **5(c)** therefor.

This second processing-mode is initiated by mounting the intra-oral tip **5(c)** with a mirror in the distal end that covers the entire optical field-of-view and directs light from the scanner device **2** towards the object to be scanned. The intra-oral tip **5(c)** is shown mounted in **Fig. 4**. This tip is configured for being inserted into the mouth of a patient. Further, in one configuration of the scanning-device **2**, the light is selected to trans-illuminate the object to be scanned.

When the scanning tip **5(c)** is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip **5(c)** which is stored on an internal memory of the scanning tip **5(c)**. The identification-number is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images

15 recorded with an infrared-light illumination on the object. To do this, the scanner device **2** is configured to illuminate the object with infrared light into the object, for example into a tooth, and the surrounding gingiva. The scanning tip **5(c)** is configured such that the red light propagates through the gum and tooth material to illuminate the tooth from the inside. The infrared light illumination is controlled by the controller **8** and based on the scanner-tip identification-number **17**. In other words, when the controller **8** receives the scanner-tip identification-number **17**, the controller **8** additionally instructs the scanner device **2** to emit the infrared light. Instructions **19** from the controller and to the tip **5(c)** are shown in **Fig. 4**. Further, the controller **8** additionally instructs the scanner device **2** to emit the white light.

In this manner, a regular sequence of images **15** is recorded with the white-light illumination. However, at a specific point in time, the white light recording is momentarily interrupted to record a single image **20** with infrared illumination. The interruption is based on scan data feedback **21** between the controller **8** and the scanner device **2,** the feedback **21** being also based on data **22** from the processor **7**. The data **22** from the processor **7** may for example be a 2D image index-number of the infrared image **19**. The index-number may be dynamically determined for each image in the sequence of images **15**.

Further, when in the second processing-mode, the processor **7** processes the white light images to derive both data for 3D geometry and data for texture for the surface. Further, the processor **7** processes the single infrared light image to derive data for texture of the internal structure of the object. Finally, the processor correlates data for the texture of the internal structure of the object to the data for the 3D geometry.

In this example, the scanning application correlates the infrared image **15** to a corresponding position on the 3D-model **13**.

Example 5 – Processing-mode in fluorescence scanning mode

In this example, the scanning system **1** is configured for performing intra-oral scanning of at least a portion of a tooth using at least fluorescent light.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a second processing-mode corresponding to scanning intra-orally with at least fluorescent light using a scanning-tip therefor **5(d)**.

This second processing-mode is initiated by mounting the intra-oral tip with a mirror in the distal end that covers the entire optical field-of-view and directs light from the scanner device **2** towards the object to be scanned. The intra-oral tip **5(d)** is shown mounted in **Fig. 5**. This tip is configured for being inserted into the mouth of a patient. Further, in one configuration of the scanning-device, the light is selected to excite a fluorescence material in the object to be scanned.

When the scanning tip **5(d)** is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip which is stored on an internal memory of the scanning tip **5(d)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images **15** recorded with a both white-light illumination pattern and blue-light illumination pattern on the object. To do this, the scanner device **2** is configured to illuminate the object in an alternating manner, where the light is switched between white light and blue light. The switching of light is controlled by the controller **8** and based on the scanner-tip identification-number **17**.

In other words, when the controller **8** receives the scanner-tip identification-number **17**, the controller **8** additionally instructs the scanner device **2** emit the white light and the blue light in the alternating manner. Instructions **18** from the controller and to the tip **5(d)** are shown in **Fig. 5**.

In this manner, every second image **23** contains information associated with depth information and reflective color information and every subsequent image **24** between these images **23** contains the response of emitted fluorescence texture.

In the second processing-mode, the processor **7** is instructed to bundle each pair of consecutive white light image **23** and blue light image **24** together such that the depth information of the white light image frame is attached to the fluorescence texture of the subsequent blue light image. This results in a processed data **16** for 3D geometry with less processed data for 3D geometry in comparison to **Example 2** but includes emitted fluorescent texture instead of reflected color texture. The processed data **16** is sent as a data package to a scanning application on the externally connected computer **11** responsible for generating the 3D-model **13**.

In this example, the scanning application only uses the data for the 3D geometry to locate a specific location on the 3D-model 13 to overlay the florescent color texture correctly on the 3D-model 13.

Example 6 – Processing-mode in reduced field-of-view scanning mode

In this example, the scanning system **1** is configured for performing intra-oral scanning of at least a portion of a tooth using a reduced field-of-view.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a second processing-mode corresponding to scanning intra-orally with at least a reduced field-of-view using a scanning-tip therefor **5(e)**.

This second processing-mode is initiated by mounting the scanning-tip **5(e)** with a mirror in the distal end that covers the entire optical field-of-view and directs light from the scanner device **2** towards the object to be scanned. The intra-oral tip **5(e)** is shown mounted in **Fig. 6**. This scanning-tip **5(e)** is configured for being inserted into the mouth of a patient. The field-of-view in the scanning-tip may be reduced in comparison to the scanning-tip **5(a)** described in **Example 2**, or it may have the same field-of-view as the scanning-tip **5(a)** described in **Example 2**.

When the scanning tip is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip which is stored on an internal memory of the scanning tip **5(e)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images **15** recorded with for example reduced field-of-view.

As described above, the reduced field-of-view may be due to the scanning-tip having a reduced field-of-view in comparison to the scanning tip **5(a)** described in **Example 2**. However, reduced field-of-view may additionally or alternatively be defined by the processor **7**. For example, the processor **7** may be instructed by the controller **8** to avoid processing an outer part **25** of the images which is not exposed to reflected light due to the reduced field-of-view of the scanning-tip. In other words, the processor **7** is instructed to only process a specific part **26** of each of the plurality of images to construct a reduced depth and color sub-scan.

The processed data **16** of a sub-scan is finally sent as a data package to a scanning application on the externally connected computer **11** responsible for generating the 3D-model **13**.

Example 7 – Processing-mode in enlarged field-of-view scanning mode

In this example, the scanning system **1** is configured for performing face scanning of at least a portion of a face or larger object using an enlarged field-of-view.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a second processing-mode corresponding to scanning intra-orally with at least an enlarged field-of-view using a scanning-tip therefor **5(f)**.

This second processing-mode is initiated by mounting the scanning-tip **5(f)** as shown mounted in **Fig. 7a**. The tip **5(f)** comprises an optical element for increasing the scan area to a size of more than 50 mm and volume by more than a factor of 10 compared to intra-oral scanning. The field-of-view in the scanning-tip is thus enlarged in comparison to the scanning-tip **5(a)** described in **Example 2**.

When the scanning tip is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip which is stored on an internal memory of the scanning tip **5(e)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images **15** recorded with the enlarged field-of-view. Due to the enlarged field-of-view, the processor receives distorted data. **Fig. 7** shows how the distorted data is first post-processed to post-processed data **18** and finally processed to processed data **16**. In this as well as all the **Examples 2-7**, the processor **7** operates differently dependent on the type of scanning tip being mounted. In all examples, the controller **8** is configured for controlling the operation of the processor **7** according to the type of the scanning-tip (**5a, 5b, 5c, 5d, 5e, 5f**) recognized by the recognition component **6.**

The processed data **16** is finally sent as a data package to a scanning application on the externally connected computer **11** responsible for generating the 3D-model **13**.

Different schematic versions of the scan tip **5(f)** are shown in **Fig. 7b** illustrated in **5(f)1-4** with increasing complexity.

Tip version **5(f)-1** shows an enlarged field-of-view tip with a tilted lens to avoid lens reflection directly back to the image sensor when mounted (not shown). This simple setup is easy to produce but may however create distortions whereby the scan-signal is reduced.

Tip version **5(f)-2** shows an enlarged field-of-view tip similar to **5(f)-1** but with an added quarter-wave (QW). In this example, the QW may be rotatable to minimize reflection.

Tip version **5(f)-3** shows an enlarged field-of-view tip similar to **5(f)-2** but with an additional added quarter wave plate. This configuration enables that the tip retains the polarization of the light, thus enabling the tip to be used to scan translucent objects like teeth and eyes.

Tip version **5(f)-4** shows an optimized enlarged field-of-view tip comprising several optical elements for fine-tuning the performance. This version has superior performance compared to the 5(f)1-3.

Example 8 – Processing-mode in intra-oral scanning mode

In this example, the scanning system **1** is configured for performing intra-oral scanning of at least a portion of a tooth.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a first processing-mode corresponding to scanning intra-orally using a scanning-tip **(5a)** therefor.

This first processing-mode is initiated by mounting the intra-oral tip **5(a)** with a mirror in the distal end that covers the entire optical field-of-view and directs light from the scanner device **2** towards the object to be scanned. The intra-oral tip **5(a)** is shown mounted in **Fig. 8**. This tip is configured for being inserted into the mouth of a patient.

In this example, the processor **7** processes images **15** acquired by the image sensor **3** into processed data **16** while a focus lens is adjusted. The focus lens adjustment is confined to a specific span length, where the focus lens is moved back a forth while recording a plurality of 2D-images **15** of a projected pattern on the object. The processed data **16** is extracted by processing the plurality of 2D images **15**.

When the scanning tip **5(a)** is mounted to the scanner device **2**, the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip which is stored on an internal memory of the scanning tip **5(a)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the scanner-tip identification-number **17**, the controller **8** instructs the processer **7** (in this example located external to the scanner device **2**) to process a continuous sequence of 2D-images **15** recorded with a white-light illumination pattern on the object. The white light enables that from each 2D-image, both data for 3D geometry and data for texture can be derived. In other words, the processed data **16** is in the form of data for 3D geometry and in the form of data for texture.

Accordingly, the processor **7** on the external computer **11** processes the plurality of 2D-images **15** into processed data **16**. In this example, the processed data **16** from the processor **7** is dependent on the processing-mode.

The processed data **16** is used by the external computer **11** to generate a 3D-model **13**.

Example 9 – Overview of examples of scanning-tips

Several scanning-tips **(5a, 5b, 5c, 5d, and 5e)**, as examples, are described in Example 1-8. This example provides an overview of the different scanning-tips.

Intra-oral scanning-tip to provide white light

In one example, there is provided a replaceable scanning-tip **5(a)** for a scanner device **2**, the scanning-tip **5(a)** being configured for intra-orally scanning of teeth and for providing white light to the teeth. The scanning-tip **5(a)** may be for the scanner device **2** according to the invention, or for any type of scanner device. The white light may be emitted by a white light source residing in the scanner device **2**. The replaceable scanning-tip **5(a)** may comprise a mirror located at the distal end of the scanning-tip **5(a)** with a reflective surface inside the scanning-tip such that when the mirror receives light from the white light source, the scanning tip provides light to the teeth. The mirror may also be configured for receiving white light as back-reflected from the teeth, such that when the mirror receives light from teeth, the scanning tip **5(a)** provides light to the image sensor **3**.

In-ear scanning-tip to provide white light

In another example, there is provided a replaceable scanning-tip **5(b)** for a scanner device **2**, the scanning-tip **5(b)** being configured for in-ear scanning of the inside of an ear and for providing white light to the inside of the ear. The scanning-tip **5(b)** may be for the scanner device **2** according to the invention, or for any type of scanner device. The white light may be emitted by a white light source residing in the scanner device **2**. The replaceable scanning-tip **5(b)** may comprise a mirror located at the distal end of the scanning tip **5(b)** with a reflective surface inside the scanning-tip **5(b)** such that when the mirror receives light from the white light source, the scanning-tip **5(b)** provides light to the inner ear. The mirror may also be configured for receiving white light as back-reflected from the inner ear, such that when the mirror receives white light from the inner ear, the scanning tip **5(c)** provides white light to the image sensor **3**. For the scanning-tip **5(b)** to be inserted into the ear, the mirror may be dimensioned according to dimensions of an inner ear.

Intra-oral scanning-tip to provide white light and infrared light

In a third example, there is provided a replaceable scanning-tip **5(c)** for a scanner device **2**, the scanning-tip **5(c)** being configured for intra-orally scanning of teeth and for providing white light and infrared light to the teeth. The scanning-tip **5(c)** may be for the scanner device **2** according to the invention, or for any type of scanner device. The white light may be emitted by a white light source residing in the scanner device **2**. The infrared light may be emitted by an infrared light source or a plurality of light sources located in or on the replaceable scanning-tip **5(c)**. The replaceable scanning-tip **5(c)** may comprise a mirror located at the distal end of the scanning-tip **5(c)** with a reflective surface inside the scanning-tip **5(c)** such that when the mirror receives light from the white light source, the scanning tip **5(c)** provides white light to the teeth. The mirror may also be configured for receiving white light as back-reflected from the teeth, such that when the mirror receives white light from teeth, the scanning-tip **5(c)** provides white light to the image sensor **3**. Further, the mirror may also be configured for receiving infrared light as back-reflected from the teeth, such that when the mirror receives infrared light from the teeth, the scanning tip **5(c)** provides infrared light to the image sensor **3**.

Intra-oral scanning-tip to provide white light and fluorescent light

In a fourth example, there is provided a replaceable scanning-tip **5(d)** for a scanner device **2**, the scanning-tip **5(d)** being configured for intra-orally scanning of teeth and for providing white light and infrared light to the teeth. The scanning-tip **5(c)** may be for the scanner device **2** according to the invention, or for any type of scanner device. Both the white light and fluorescent light may be emitted by a white light source and a fluorescent light source residing in the scanner device **2,** for example a single light source configured to emit both white light and fluorescent light. The replaceable scanning-tip **5(d)** may comprise a mirror located at the distal end of the scanning-tip **5(d)** with a reflective surface inside the scanning-tip **5(d)** such that when the mirror receives light from the white light source and the fluorescent light source, the scanning tip **5(d)** provides white light and fluorescent light to the teeth. The mirror may also be configured for receiving white light and fluorescent light as back-reflected from the teeth, such that when the mirror receives white light and fluorescent light from the teeth, the scanning tip **5(d)** provides white light to the image sensor **3**.

Intra-oral scanning-tip to provide white light and reduced field-of-view

In a fifth example, there is provided a replaceable scanning-tip **5(e)** for a scanner device **2**, the scanning-tip **5(e)** being configured for intra-orally scanning of teeth and for providing white light to the teeth and with a reduced field-of-view. The scanning-tip **5(e)** may be for the scanner device **2** according to the invention, or for any type of scanner device. The white light may be emitted by a white light source residing in the scanner device **2**. The replaceable scanning-tip **5(e)** may comprise a mirror located at the distal end of the scanning-tip **5(e)** with a reflective surface inside the scanning-tip such that when the mirror receives light from the white light source, the scanning tip provides light to the teeth with a reduced field of view. The mirror may also be configured for receiving white light as back-reflected from the teeth, such that when the mirror receives light from teeth, the scanning tip **5(e)** provides light to the image sensor **3**.

Face scanning-tip to provide white light and enlarged field-of-view

In a sixth example, there is provided a replaceable scanning-tip **5(e)** for a scanner device **2**, the scanning-tip **5(f)** being configured for surface scanning of a face and for providing white light to the face and with an enlarged field-of-view. The scanning-tip **5(e)** may be for the scanner device **2** according to the invention, or for any type of scanner device. The white light may be emitted by a white light source residing in the scanner device **2**. The replaceable scanning-tip **5(e)** may be open-ended such that when the mirror receives light from the white light source, the scanning-tip **5(f)** provides light to the face with an enlarged field of view. The open-ended opening may be configured for receiving white light as back-reflected from the face, such that when the open-ended opening receives light from face, the scanning tip **5(f)** provides light to the image sensor **3**.

Example 10 – Processing-mode in dual angle mirror scanning mode

In this example, the scanning system **1** is configured for performing smooth scanning, providing that data can be obtained from challenging areas. These areas may for example be the mesial surface of the 2nd or 3rd molars and the so-called anterior crossover. When performing a full jaw intraoral scan, the scanning session is typically initiated on the occlusal surface of a molar. The digital model of the jaw is continuously generated as the scanner device is moved along the dental arch. At some point, the scanner device is moved across the canines and incisal edge. This area is particularly challenging for the scanner device as the top view of the teeth is very small due to the nature of the tooth morphology, which results in a limited 3D-information. Typically, this situation is handled by instructing the operator to perform a wiggling scanning movement, to continuously record the facial and lingual/palatal surfaces in order to ease an accurate model reconstruction. The scanning probe show in **Fig. 9** solves this issue by using a dual angle mirror scan tip **5(g)** which is configured for simultaneously recording 3D-data from an object from multiple angles, hence creating larger patches of 3D-data. Accordingly, this tip is configured to access areas in the oral cavity, which are otherwise hard to reach.

Further, in this example, the scanning system **1**, more particularly the processor **7**, is configured to operate in a second processing-mode corresponding to scanning intra-orally with at least a split-view using a dual angle mirror scanning-tip therefor **5(g)**.

This second processing-mode is initiated by mounting the dual-angle-mirror-scanning-tip **5(g)** with optical element in the distal end separated in at least 2 individual reflecting segments with different angles relative to the incident light originating from the scanner device. The individual reflecting segments cover the entire optical field-of-view and directs light from the scanner device **2** (not shown) towards the object to be scanned. The distal part of the tip **5(g)** is shown from a cross sectional view in **Fig. 9**. The tip **5(g)** comprises an optical element comprising a first segment **28** and a second segment **29**. The two reflecting segments are arranged such that light reflected from the second segment **29** is directed towards the object to be scanned in a different angle then then the light reflected from the first segment **28**. The two segments **28** and **29** are positioned such that the individual field-of-view from the segments overlap by a substantial amount in the entire scan volume **30**. The combined field-of-view in the dual-angle-mirror scanning-tip is thus different in comparison to the scanning-tip **5(a)** described in **Example 2**.

When the dual-angle-mirror scanning tip is mounted to the scanner device **2** (not shown), the scanner device **2** reads recognition data **17** in the form of an identification-number **17** of the tip which is stored on an internal memory of the scanning tip **5(g)**. The identification-number **17** is forwarded to the controller **8** located on the externally connected computer **11**. Based on the dual-angle-mirror scanner-tip identification-number **17**, the controller **8** instructs the processer **7** on the scanner device **2** to process a continuous sequence of 2D-images **15** recorded with the mixed field-of-view. Due to the mixed field-of-view, the processor receives distorted data containing 3D-information from the same object view from different directions mixed together.

Fig. 9 shows how the mixed data (recorded with the two segments **28** and **29**) is first post-processed to post-processed data **18** and finally processed to processed data **16**.

By comparison, **Example 1** only had one mirror that was located in the tip, whereby each point in the scan volume (i.e. the volume in which the scanner device was able to collect data) maps 1-to-1 to a pixel in an image. In this example, when the dual angle mirror tip **5(g)** is attached, the geometry of the scan volume becomes more complicated, and there may be points in the scan volume **30** that can be simultaneously recorded from both mirror segments **28** and **29**, and hence map to more than one pixel.

The data processing of mapping between scan volume and depth image and vice versa is used for registration and reconstruction of the 3D-model. These transformations are modeled together with a dedicated automatic calibration routine. Accordingly, in this example, the processor **7** operates differently dependent on the type of scanning-tip being mounted. In all examples, the controller **8** is configured for controlling the operation of the processor **7** according to the type of the scanning-tip (**5a, 5b, 5c, 5d, 5e, 5f, 5g**) recognized by the recognition component **6.**

The processed data **16** is finally sent as a data package to a scanning application on the externally connected computer **11** responsible for generating the 3D-model **13**.

Example 11 – A user-interface

A dedicated user-interface is shown in **Fig. 10(a-e)**. A first part of the purpose of the user-interface is to guide the operator through a scanning session whereby the operator is guided to use a first scanning-tip and then to use a second scanning-tip. Another part of the purpose of the user-interface is to efficiently provide a 3D-model, by at least changing the process dependent on the input from the user. This example will show how a 3D-model is efficiently provided.

Typically, a 3D-model from an edentulous patient may be challenging to provide. Further, scanning may be difficult due to the lack of clear landmarks in the toothless jaw. Unbound gingiva may also shift around during scanning and create difficulty for registration algorithms relying on rigid objects to be scanned. A computer-implemented method with instructions to use the scan tip from **Example 7** as well as the regular scan tip from **Example 2** is demonstrated in the following.

The example illustrates a computer-implemented method for generating a 3D-representation **13** of an oral cavity displayed in a graphical user-interface **30** on a screen in the following steps:

First, shown in **Fig 10a**, the user is presented with a display having a plurality of options for scanning **31**, such that a user is instructed, in the user-interface, to select one of said options for scanning **32**. For example, in the present case, the operator wants to scan an edentulous patient, and the operator therefore selects the option to scan in relation to e.g. a full denture **32**, for example by using a screen cursor (via a pointing device), and/or by clicking on the screen, and/or by using the scanner device.

Upon selection of the scan option, **32**, the display will shift to the display as shown in **Fig 10b.** Based on the one option for scanning **32**, as received by the computer-implemented method, the computer-implemented method provides instructions **33** for the user to mount a first scanning-tip a scanner device. In this case, the user-interface prompts the user to mount an enlarged field-of-view tip **5(f)** to the scanner device **2**.

Due to a recognition component in the scanner device **2**, both the scanner device **2** and the computer-implemented method registers that the tip **5(f)** is mounted. Hereafter, the computer-implemented method proceeds to the next step in the process of generating a 3D-model. In some embodiments, the scanning system may additionally prompt the user to perform an optical calibration to the mounted tip **5(f)**. The calibration may be pre-recorded.

The computer-implemented method receives first information from the scanner device **2** related to the mounted scanning-tip when mounted properly on the scanner device **2**. This enables the computer implemented method to change display mode and direct the user into a scanning display as shown in **Fig. 10c**. The change in display mode into the scanning display is by itself a first scanning indication **34** for the user to scan with the scanner device **2** having mounted the first scanning-tip **5(f)**.

As just explained, and according to the second aspect of the invention, the computer-implemented method displays, in the graphical user-interface, and based on the first information from the scanner device **2**, first scanning instruction **34** and/or first scanning indication **34** for the user to scan with the scanner device **2** having mounted the first scanning-tip **5(f)**.

In this case, and when in the display mode of the scanning display, the graphical user-interface further displays a live-view-box as an additional part of the first scanning indication **34** (right lower corner of **Fig. 10c**), and a 3D-view-box (in the middle of **Fig. 10c**) where the 3D-model **13** is generated, or to be generated, as another additional part of the first scanning indication.

After changing to the scanning display, scanning with the scanning device **2** may be initiated by pressing a scan button on the scanner device or on the screen in the user-interface. In some embodiments, the live-view box and/or the 3D-view box may appear on the scanning display after initiating scanning.

Further, in the scanning display (**Fig. 10c**) as indicating the first scanning indication **34** for the user to scan with the scanner device **2**, the system receives scan data from the scanner device, which is used to construct a first part of the 3D-representation **13(a)**.

Here, the jaw is scanned with the enlarged field-of-view tip **5(f)**. The enlarged field-of-view tip **5(f)** is located outside the mouth or only slightly inserted into the mouth. Since the enlarged field-of-view tip **5(f)** has a field-of-view that covers a substantial part of the entire jaw (as shown in the live view box **34**) (e.g. 50% of the jaw), the registration relies on the overall jaw structure. The enlarged field-of view scan tip **5(f)** of the entire jaw is not adequate for clinical purposes. It may only cover the buccal side of the jaw since the tip **5(f)** cannot be inserted deep into the mouth and moved around to obtain images from e.g. the lingual side. The enlarged field-of-view tip **5(f)** also has a lower resolution since it expands the field-of-view of the scanning device **2**. Therefore, in this case, a more detailed scan with a regular scan tip **5(a)** may be used to satisfy the clinical needs. Thus, when a sufficient portion of the jaw has been scanned with the enlarged field-of-view tip **5(f)**, the user may confirm that the first part of the 3D-representation **13(a)** as generated is sufficient by clicking a “next button” **35** to continue to generate the final 3D-model **13c**. Accordingly, the user has here provided confirmation-input by clicking on the “next button” **35**, wherein the confirmation-input comprise information confirming that the first part of the 3D-representation **13(a)** as generated is sufficient. In this case, the user has determined that the first part of the 3D-model **13(a)** as shown in **Fig. 10c** is sufficient.
The user may generate several first parts of the 3D-representation **13(a)**, for example a lower jaw and an upper jaw. Accordingly, the user may confirm several times that the first part of the 3D-representation **13(a)** as generated is sufficient, for example by clicking the first “next button” **35** (indicating that the lower jaw is sufficient) and then a second “next button” **36** (indicating that the upper jaw is sufficient) to continue to generate the complete 3D-model **13(c)**.

In addition, the first part of the 3D-representation **13(a)** as confirmed sufficient may be collected over time from the user, and/or a plurality of different users. These 3D-representations **13(a)** may thereby form historical 3D-representations as confirmed sufficient, whereby the step of displaying the instructions to replace the first scanning-tip with a second scanning-tip is automatized and based on the historical 3D-representations as confirmed sufficient. In other words, the step of confirming that the first 3D-representation **13(a)** is sufficient may be taken over by an automized procedure based on the historical 3D-representations. For example, the historical 3D-represenations as confirmed sufficient may be used as input for an algorithm configured to determine when the first part of the 3D-representation **13(a)** as generated is sufficient, and wherein the algorithm is based on averaging the historical 3D-representations, and/or wherein the algorithm is based on machine learning and/or artificial intelligence (AI). Accordingly, the input as provided by the user changes the process of obtaining the final 3D-representation **13(c)**. For example, due to the input from the user(s), the user interface may change such that it is no longer possible to press the "next button". Instead the "next button" may automatically be ticked with a green tick in the "next buttons" **35** and **36**, once the first 3D representation **13a** is sufficient. Thereby, the input from the user makes the process of generating the final 3D-representation **13(c)** much more efficient, and in fact also more reliable.

In addition to the judgement from the user(s), the human jaw has a certain, recognizable shape, and thus it may also be possible to teach the algorithm to analyze such shape. Accordingly, the algorithm may in addition to the user input be optimized. AI assisted data analysis may be enabled or disabled in the user-interface.

Upon completion of the entire jaw scan(s) with the enlarged field-of-view tip **5(f)**, the computer implemented method prompts the operator with a second mounting instruction **37** to mount the regular scan tip **5(a)**, thus by replacing the first scanning-tip **5(f)** with the second scanning tip **5(a)**. This is shown in **Fig. 10d**.

If the regular tip **5(a)** is a tip with electronics, the computer-implemented method may register that the regular tip **5(a)** is mounted and the computer-implemented method may then proceed to the next step in the computer-implemented method. If the tip **5(a)** is not a tip with electronic connectors, it may be possible for the computer-implemented method to identify the tip **5(a)** by analyzing visual characteristics of the recorded images in the scanner device **2**. This may also allow the computer-implemented method to continue to the next step in the computer-implemented method.

As just described, and displayed in **Fig. 10d,** the user-interface, based on the first scan data as received, now displays instructions **37** to replace the first scanning-tip with a second scanning-tip **5(a)**. The user is prompted to replace the enlarged field-of-view tip **5(f)** by a standard scan tip **5(a)** to complete the model. Again, the computer-implemented method recognizes the replacement of the scan tip and directs the user back to the scanning display (now shown in **Fig. 10e**, but similar to the scanning display in Fig. 10c) in the user-interface to continue scanning with the standard scan tip **5(a)**. The standard tip **5(a)** is configured to scan inside the oral cavity and is easily maneuvered around to capture data from different angles.

During scanning, the computer-implemented method receives second scan data from the scanner device **2** with the second scanning-tip **5(f)**, wherefrom a second part of the 3D-representation **13(b)** is generated. The second part of the 3D-representation **13(b)**, and as shown in **Fig. 10e,** may be from areas, which were not reached (or properly resolved) with the first (enlarged field-of-view) scanning-tip **5(f)**. The second part of the 3D-representation **13(b)**, which is in the form of patches (due to being recorded with a smaller field-of-view scanning-tip **5(a)** (also seen in the live-view box 34 in the lower left corner)I n comparison to the enlarged field of view scanning-tip **5(f)**) are recorded and registered onto the first part of the 3D-representation **13(a)** to obtain a complete 3D-model **13(c)**. In other words, the patches as just described have a high degree of details. These patches are thus registered onto the first partial model (the first 3D-representation **13a**) which is used as the framework for the reconstruction of the full model **13(c)**. In this manner, small registrations errors are avoided.

The end-result, here of a single jaw, is a final 3D-registration **13(c)** displayed in **Fig. 10f.**

Claims:

1. A scanning system for scanning an object, comprising:

- a scanner device comprising:
  - o an image sensor for acquiring images;
  - o a mounting-interface for detachably mounting at least one of a plurality of types of scanning-tips, wherein each of the plurality of types scanning-tips is configured for providing light to the object in an illumination-mode that differs for each of the plurality of types of scanning-tips; and
  - o a recognition component for recognizing the type of scanning-tip mounted to the mounting-interface;
- a processor configured for processing the images acquired by the image sensor into processed data; and
- a controller configured for controlling the operation of the processor according to the type of the scanning-tip recognized by the recognition component, wherein the controller is further configured for controlling the processor such that when a first type of scanning-tip is mounted and recognized, the processor is controlled to operate in a first processing-mode corresponding to the first type of scanning-tip, and such that when a second type of scanning-tip is mounted and recognized, the processor is controlled to operate in a second processing-mode corresponding to the second type of scanning-tip, wherein the second processing-mode is different from the first processing-mode, and wherein:
  - o when in the first processing mode, the processor processes a first plurality of images acquired with a first illumination-mode to provide the processed data in the form of first data for 3D geometry and first data for texture of the object,

    wherein the first data for the 3D geometry is based on:

    - ▪ a first subset of the first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and/or

        - a first subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and

      wherein the first data for the texture of the object is based on:

        - a second subset of the first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and/or
        - a second subset of pixels within said first plurality of images being selected according to the first type of scanning tip, thereby defining part of the first processing mode, and

    - when in the second processing mode, the processor processes a second plurality of images acquired with a second illumination-mode to provide the processed data in the form of second data for 3D geometry and second data for texture of the object,

      wherein the second data for the 3D geometry is based on:

        - a first subset of the second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode, and/or
        - a first subset of pixels within said second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode,

      wherein the second data for the texture of the object is based on:

        - a second subset of the second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode, and/or
        - a second subset of pixels within said second plurality of images being selected according to the second type of scanning tip, thereby defining part of the second processing mode.

2. The scanning system according to any of the preceding claims, wherein the processor is integrated in the scanner device.

3. The scanning system according to any of the preceding claims, wherein the controller is external to the scanner device.

4. The scanning system according to any of the preceding claims, wherein the type of scanning-tip, as recognized by the recognition component, is in the form of recognition-data, and wherein the scanner device is configured to transmit the recognition-data to the controller.

5. The scanning system according to any of the preceding claims, wherein the recognition element comprises a memory-reader configured to read recognition-data from an integrated memory on each of the plurality of types scanning-tips.

6. The scanning system according to any of the preceding claims, wherein the illumination-mode for one type of scanning-tip is defined by the wavelength of the light and/or wherein the illumination-mode for one type of scanning tip is defined by the intensity of the light.

7. The scanning system according to any of the preceding claims, wherein the illumination-mode for one type of scanning-tip is defined by different wavelengths of the light, whereby one type of scanning-tip switches between the different wavelengths of the light.

8. The scanning system according to any of the preceding claims, wherein the illumination-mode for one type of scanning-tip is defined by the field-of-view of the light and/or wherein the illumination-mode for one type of scanning-tip is defined by a pattern of the light.

9. The scanning system according to any of the preceding claims, wherein the first data for the 3D geometry is based on the first subset of the first plurality of

images, and the first subset of pixels within said first plurality of images, and wherein the first data for the texture of the object is based on the second subset of the first plurality of images and the second subset of pixels within said first plurality of images,
wherein the first subset of the first plurality of images is identical to the second subset of the first plurality of images, and
wherein the first subset of pixels within said first plurality of images is different from the second subset of pixels within said first plurality of images.

10. The scanning system according to any of the preceding claims, wherein the first data for the 3D geometry is based on the first subset of the first plurality of images, and the first subset of pixels within said first plurality of images, and wherein the first data for the texture of the object is based on the second subset of the first plurality of images and the second subset of pixels within said first plurality of images,
wherein the first subset of the first plurality of images is different from the second subset of the first plurality of images, and
wherein the first subset of pixels within said first plurality of images is different from the second subset of pixels within said first plurality of images.

11. The scanning system according to any of the preceding claims, wherein the first data for the 3D geometry is based on the first subset of the first plurality of images, and the first subset of pixels within said first plurality of images, and wherein the first data for the texture of the object is based on the second subset of the first plurality of images and the second subset of pixels within said first plurality of images,
wherein the first subset of the first plurality of images is different from the second subset of the first plurality of images, and
wherein the first subset of pixels within said first plurality of images is identical to the second subset of pixels within said first plurality of images.

12. The scanning system according to claim 10, wherein the first subset of the first plurality of images is every second image of the plurality of images as recorded with non-chromatic light at a plurality of wavelengths, and wherein the second subset of the first plurality of images is the remaining images of the plurality of images recorded with monochromatic light at a first wavelength.

13. The scanning system according to claim 10, wherein the first subset of the first plurality of images is every third image of the first plurality of images as recorded with non-chromatic light defined by a plurality of wavelengths, and wherein the second subset of the first plurality of images is the remaining images of the first plurality of images recorded with monochromatic light at a first wavelength and at a second wavelength.

14. The scanning system according to claim 9, wherein the second subset of the first plurality of images is a single image as recorded with non-chromatic light defined by a plurality of wavelengths.

15. The scanning system according to any of the preceding claims, wherein the second data for the 3D geometry is based on the first subset of the second plurality of images, and the first subset of pixels within said second plurality of images, and wherein the second data for the texture of the object is based on the second subset of the second plurality of images and the second subset of pixels within said second plurality of images,
wherein the first subset of the second plurality of images is identical to the second subset of the second plurality of images, and
wherein the first subset of pixels within said second plurality of images is different from the second subset of pixels within said second plurality of images.

16. The scanning system according to any of the preceding claims, wherein the second data for the 3D geometry is based on the first subset of the second plurality of images, and the first subset of pixels within said second plurality of

images, and wherein the second data for the texture of the object is based on the second subset of the second plurality of images and the second subset of pixels within said second plurality of images,
wherein the first subset of the second plurality of images is different from the second subset of the second plurality of images, and
wherein the first subset of pixels within said second plurality of images is different from the second subset of pixels within said second plurality of images.

17. The scanning system according to any of the preceding claims, wherein the second data for the 3D geometry is based on the first subset of the second plurality of images, and the first subset of pixels within said second plurality of images, and wherein the first data for the texture of the object is based on the second subset of the second plurality of images and the second subset of pixels within said second plurality of images,
wherein the first subset of the second plurality of images is different from the second subset of the second plurality of images, and
wherein the first subset of pixels within said second plurality of images is identical to the second subset of pixels within said second plurality of images.

18. The scanning system according to any of the preceding claims, wherein the scanner device further comprises a lens configured to translate back and forth while the first and/or second plurality of images is acquired.

19. The scanning system according to any of the previous claims, wherein the scanning system further comprises a processor configured to generate a 3D-model of the object, and
wherein the 3D-model is generated based on the first data for the 3D geometry, but wherein the 3D-model is not generated based on the second data for the 3D geometry, or
wherein the 3D-model is generated based on the second data for the 3D geometry, but wherein the 3D-model is not generated based on the first data for

the 3D geometry.

20. The scanning system according to claim 19, wherein when the 3D-model is not generated based on the second data for the 3D geometry, then the second data for the 3D geometry is compared to the first data for the 3D geometry, whereby the second data for texture of the object is matched to the 3D-model.

21. The scanning system according to claim 19, wherein when the 3D-model is not generated based on the first data for the 3D geometry, then the first data for the 3D geometry is compared to the second data for the 3D geometry, whereby the first data for texture of the object is matched to the 3D-model.

22. A computer-implemented method for generating a 3D-representation of an oral cavity displayed in a graphical user-interface on a screen, comprising the steps of:

- displaying, in the graphical user-interface, a plurality of options for scanning, such that a user is instructed, in the user-interface, to select one of said options for scanning;
- receiving, by the user, one or more of said options for scanning;
- displaying, in the graphical user-interface, and based on the one option for scanning as received, first mounting-instructions for the user to mount a first scanning-tip to a scanner device;
- receiving first information from the scanner device related to the first scanning-tip when the first scanning-tip is mounted to the scanner device;
- displaying, in the graphical user-interface, and based on the first information from the scanner device, a first scanning instruction and/or a first scanning indication for the user to scan with the scanner device having mounted the first scanning-tip;
- receiving first scan data by the scanner device with the first scanning-tip, wherefrom a first part of the 3D-representation is generated;
- displaying, in the graphical user-interface, and based on the first scan data as received, second mounting-instructions to replace the first scanning-tip with a second scanning-tip;

- receiving second information from the scanner device related to the second scanning-tip when the second scanning tip is mounted to the scanner device;
- displaying, in the graphical user-interface, and based on the second information from the scanner device, a second scanning instruction and/or second scanning indication for the user to scan with the scanner device having the second scanning-tip; and
- receiving second scan data by the scanner device with the second scanning-tip, wherefrom a second part of the 3D-representation is generated.

23. The computer-implemented method according to claim 22, wherein the one of said options for scanning is related to edentulous scanning.

24. The computer-implemented method according to any of the previous claims 22-23, wherein the step of receiving, by the user, one or more of said options for scanning is provided by the user clicking on the one or more of said options in the user-interface.

25. The computer-implemented method according to any of the previous claims 22-24, wherein the step of receiving the first information from the scanner device related to the first scanning-tip and/or the step of receiving the second information from the scanner device related to the second scanning-tip is provided from a recognition component in the scanner device that recognizes the type of scanning-tip when mounted to the scanner device.

26. The computer-implemented method according to any of the previous claims 22-24, wherein the step of receiving the first information from the scanner device related to the first scanning-tip is provided from visual recognition of at least a part of the first scanning-tip in the field of view of the first scanning-tip and/or the step of receiving the second information from the scanner device related to the second scanning-tip is provided from visual recognition of at least a part of the

second scanning-tip in the field-of-view of the second scanning-tip .

27. The computer-implemented method according to any of the previous claims 22-26, wherein the first scanning-tip is configured for scanning with a larger field-of-view in comparison to the second scanning-tip, whereby the first part of the 3D-representation is used as a reference model for the second part of the 3D-representation being matched to the reference model.

28. The computer-implemented method according to any of the previous claims 22-27, wherein the step of displaying instructions to replace the first scanning-tip with a second scanning-tip is based on confirmation-input from a user, wherein the confirmation-input comprise information confirming that the first part of the 3D-representation as generated is sufficient.

29. The computer-implemented method according to claim 28, wherein the first part of the 3D-representation, as confirmed sufficient, is collected over time from:
    - the user, and/or
    - a plurality of different users,

    thereby forming historical 3D-representations as confirmed sufficient, whereby the step of displaying the instructions to replace the first scanning-tip with a second scanning-tip is automatized and based on the historical 3D-representations as confirmed sufficient.

30. The computer-implemented method according to claim 29, wherein the historical 3D-represenations as confirmed sufficient is used as input for an algorithm configured to determine when the 3D-representation as generated is sufficient, and wherein the algorithm is based on averaging the historical 3D-representations, and/or wherein the algorithm is based on machine learning and/or artificial intelligence.

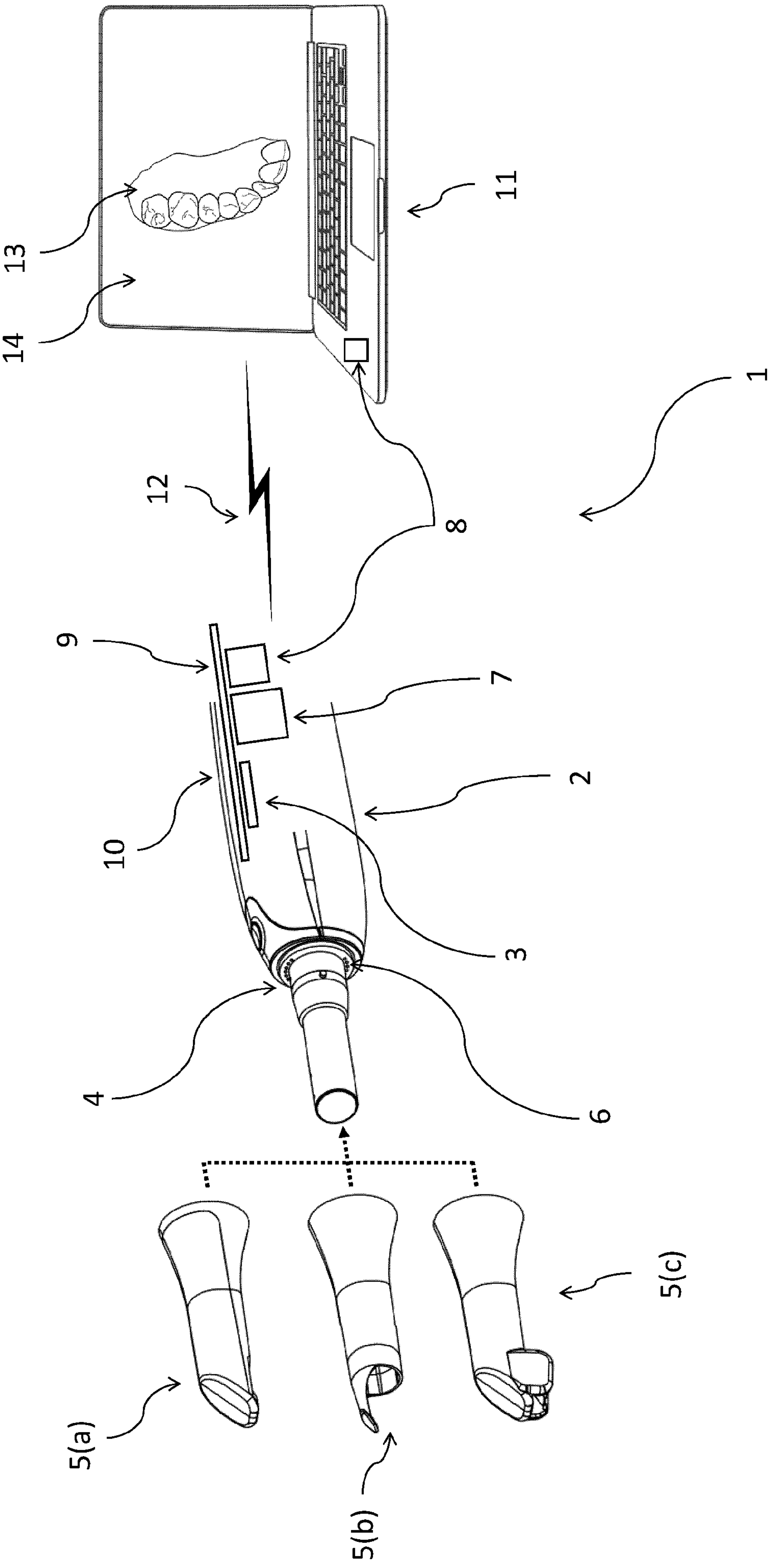

Fig. 1

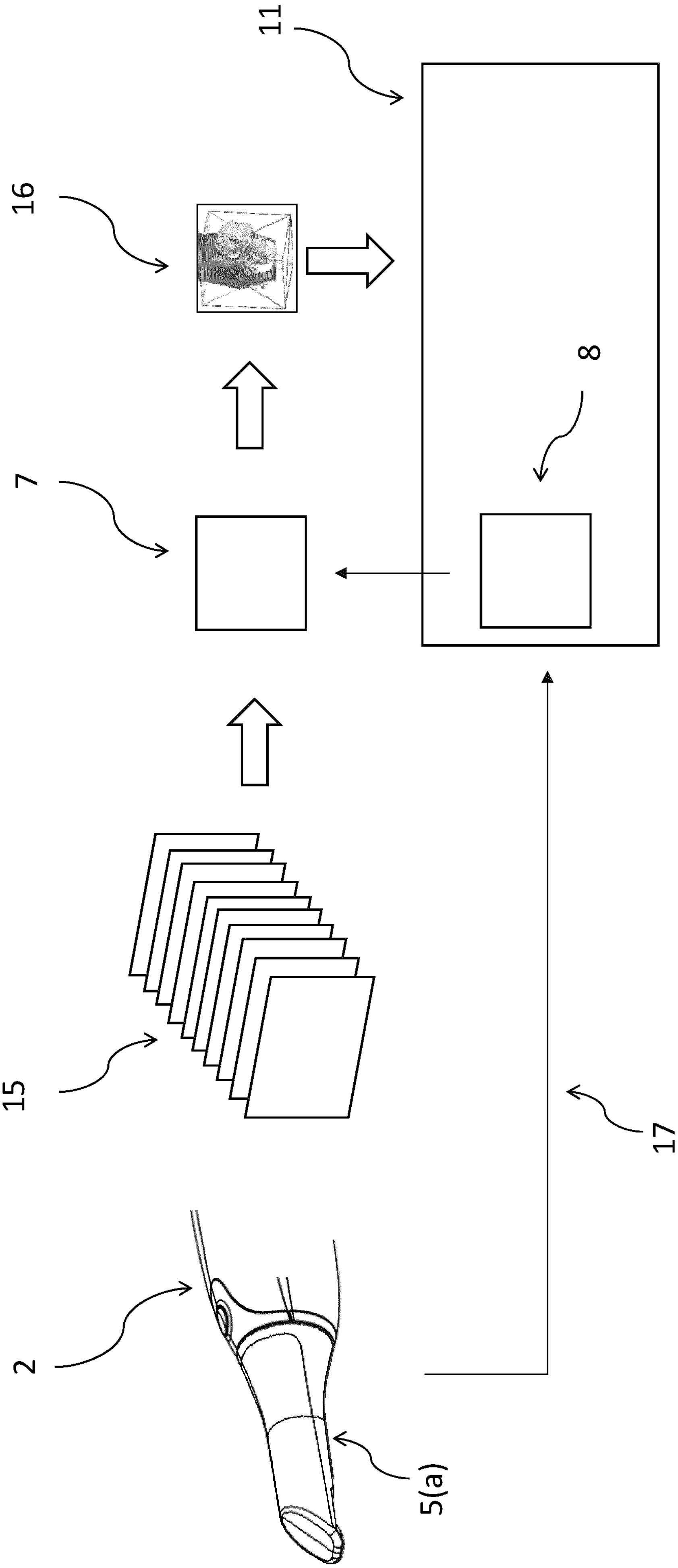

Fig. 2

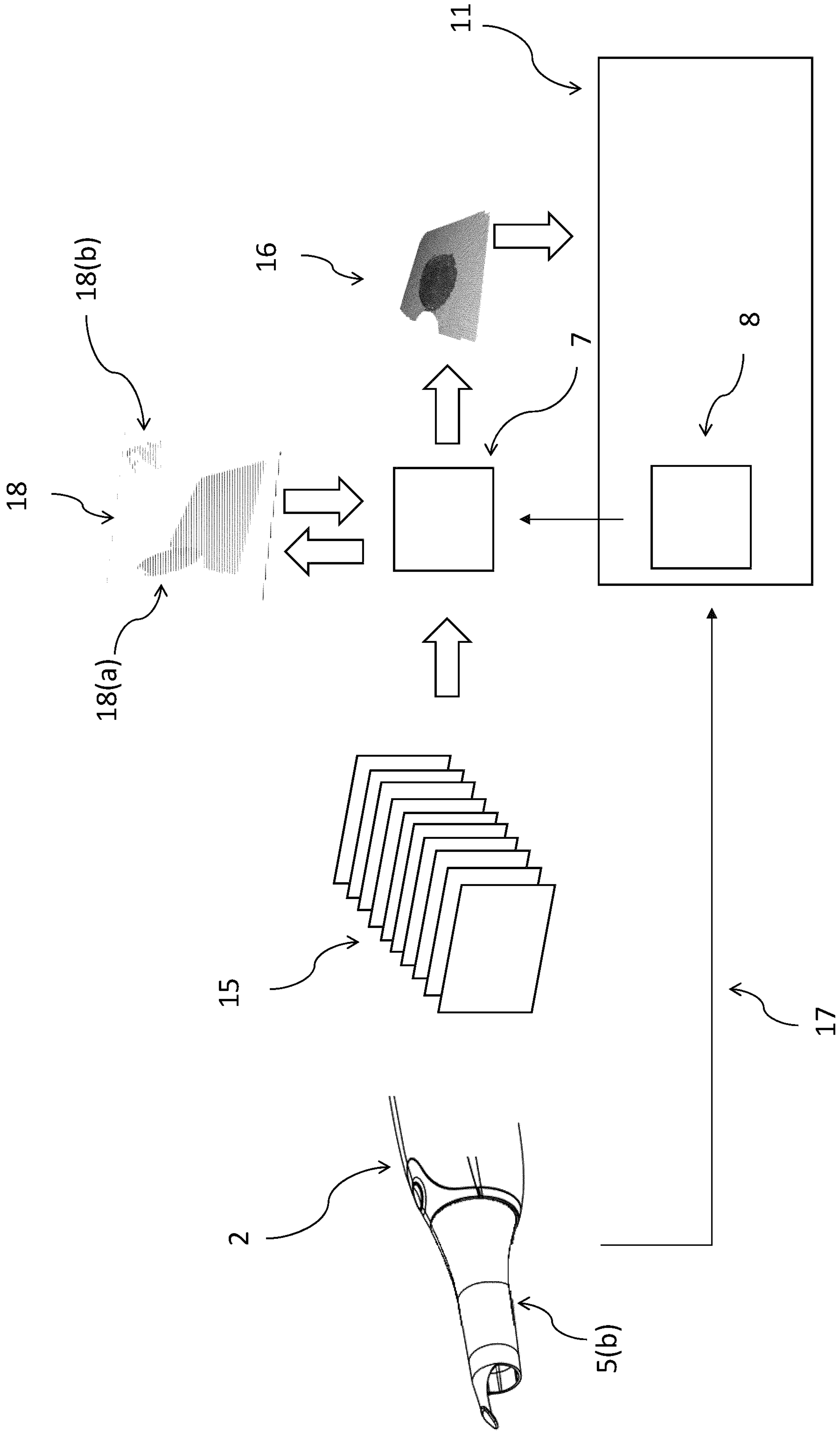

Fig. 3

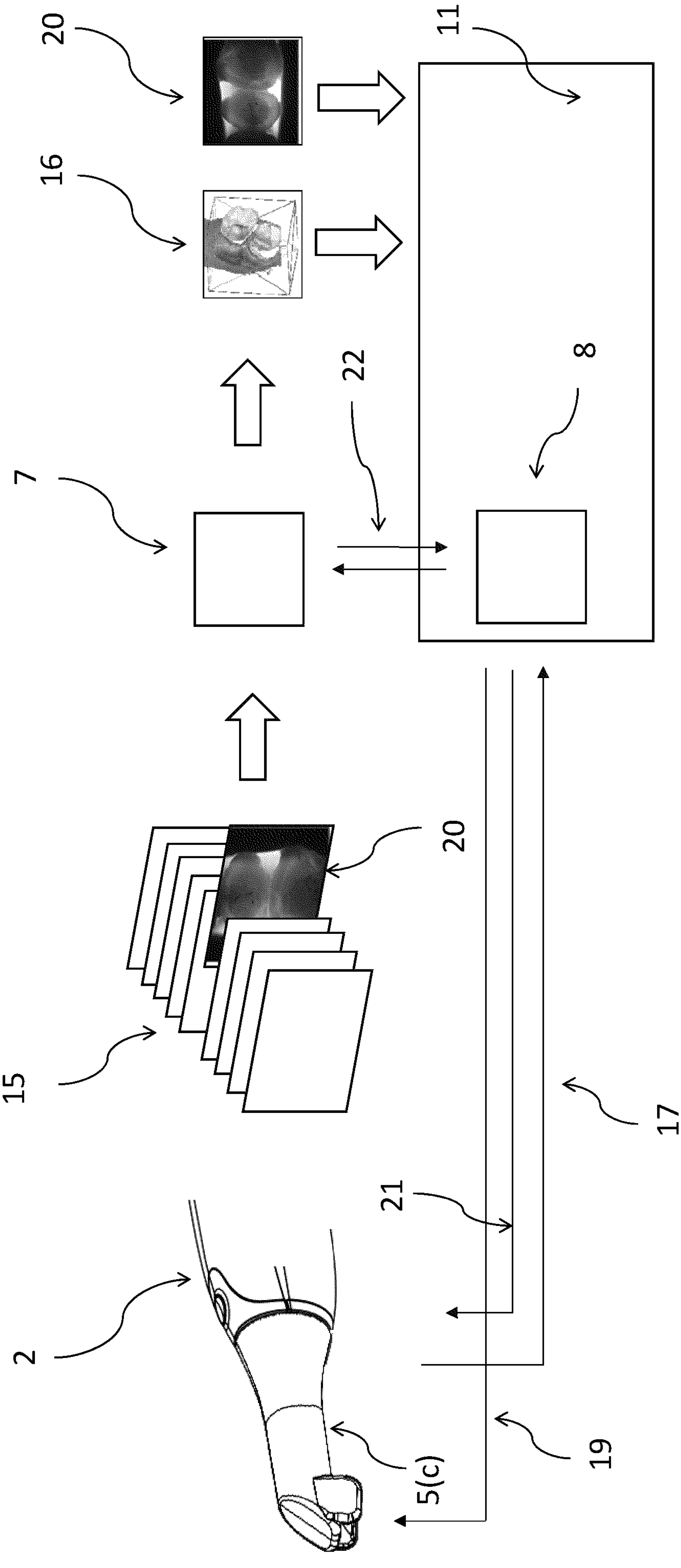

Fig. 4

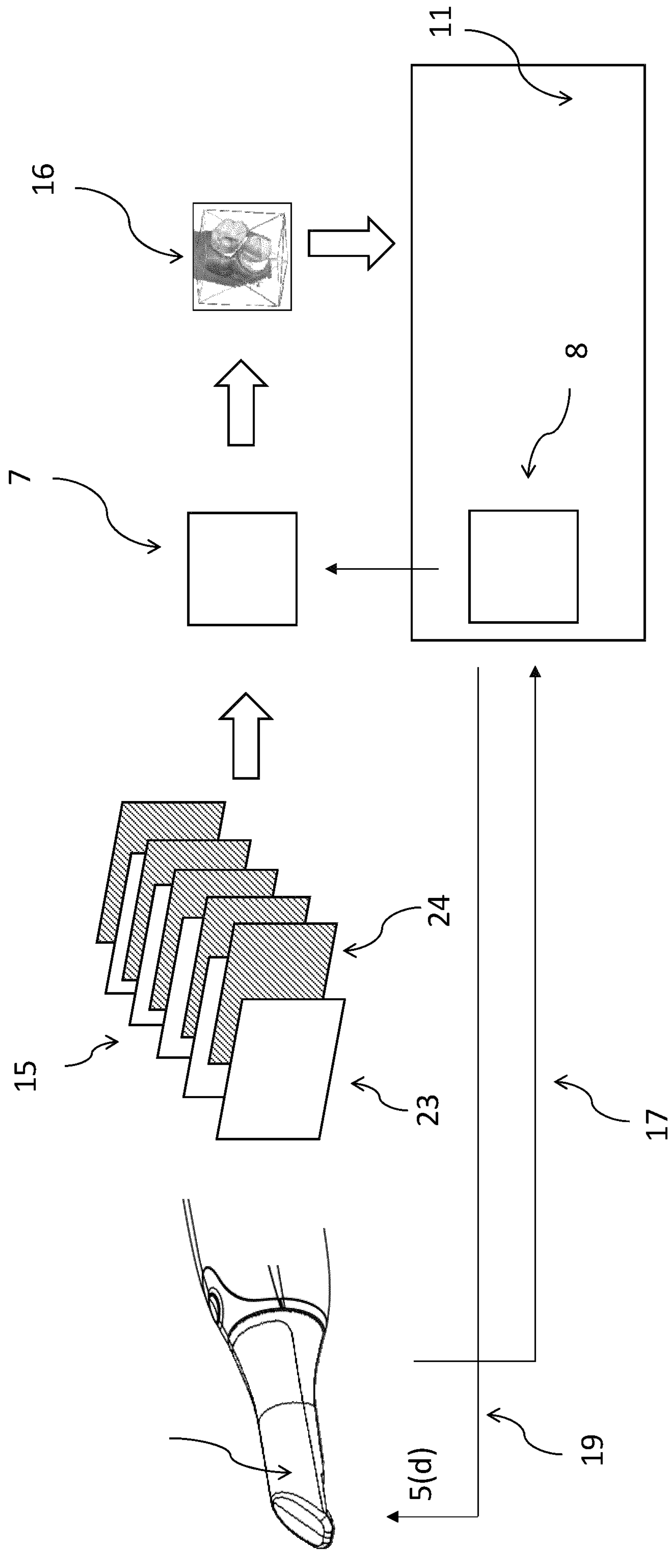

Fig. 5

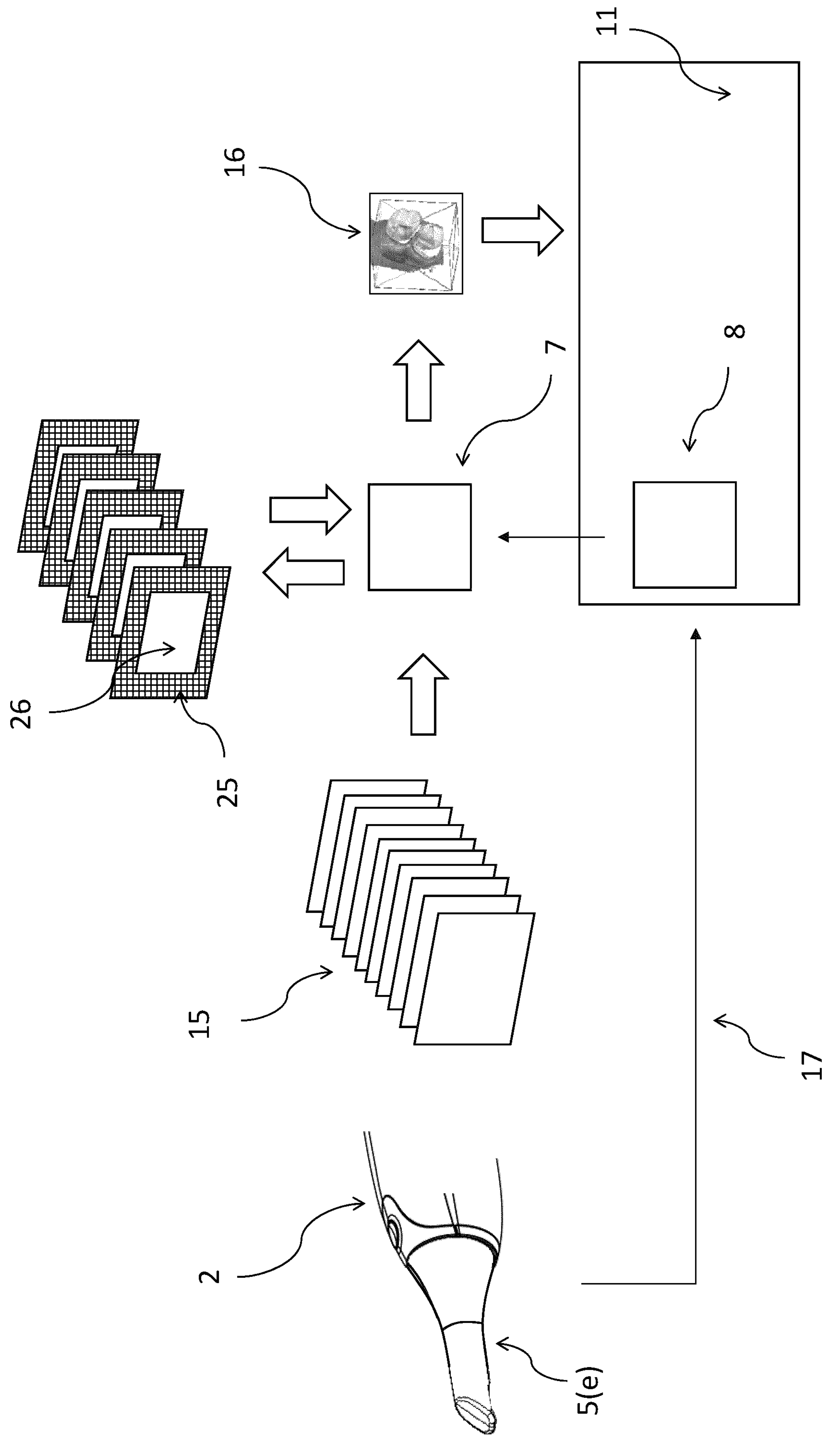

Fig. 6

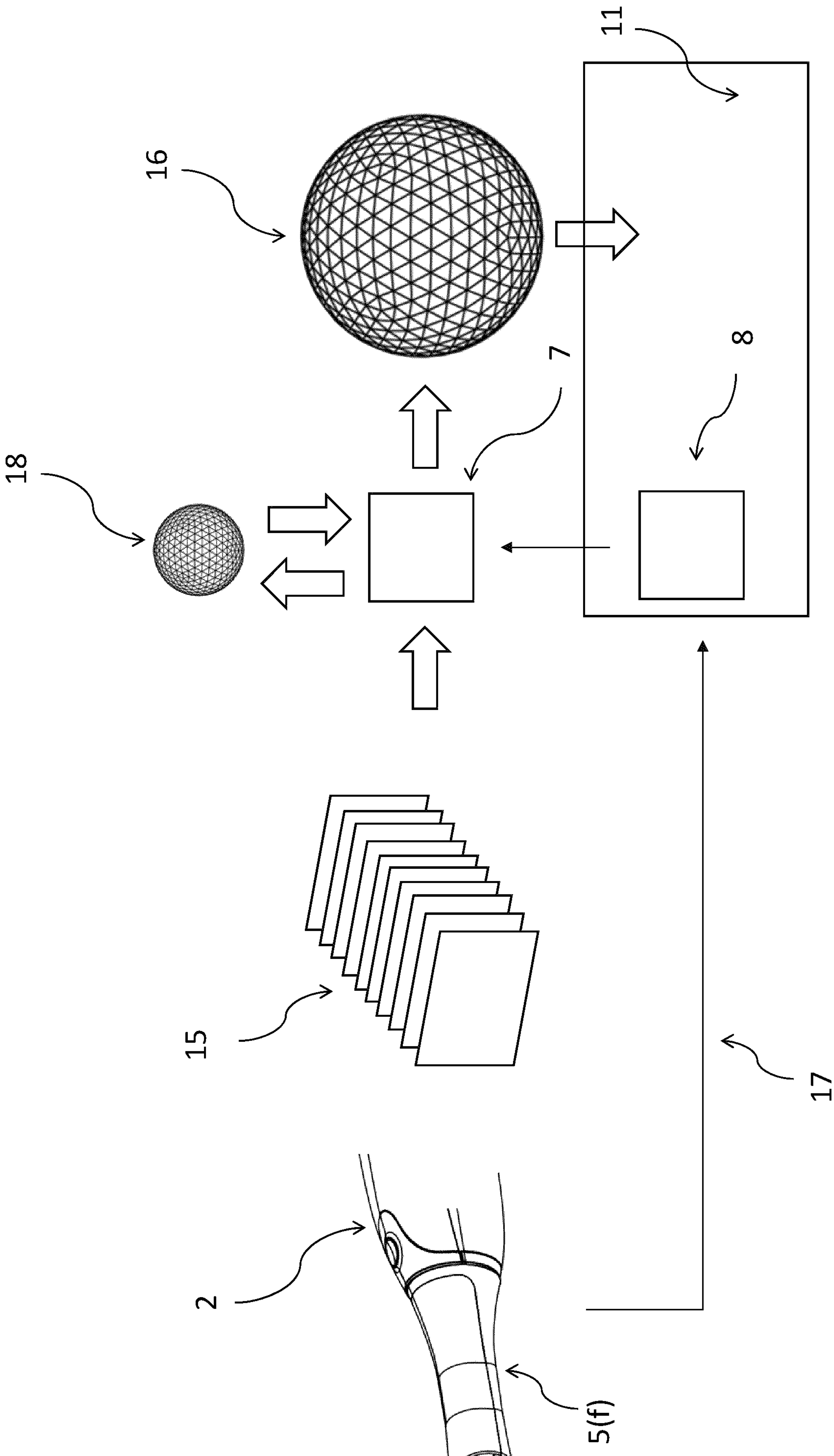

Fig. 7a

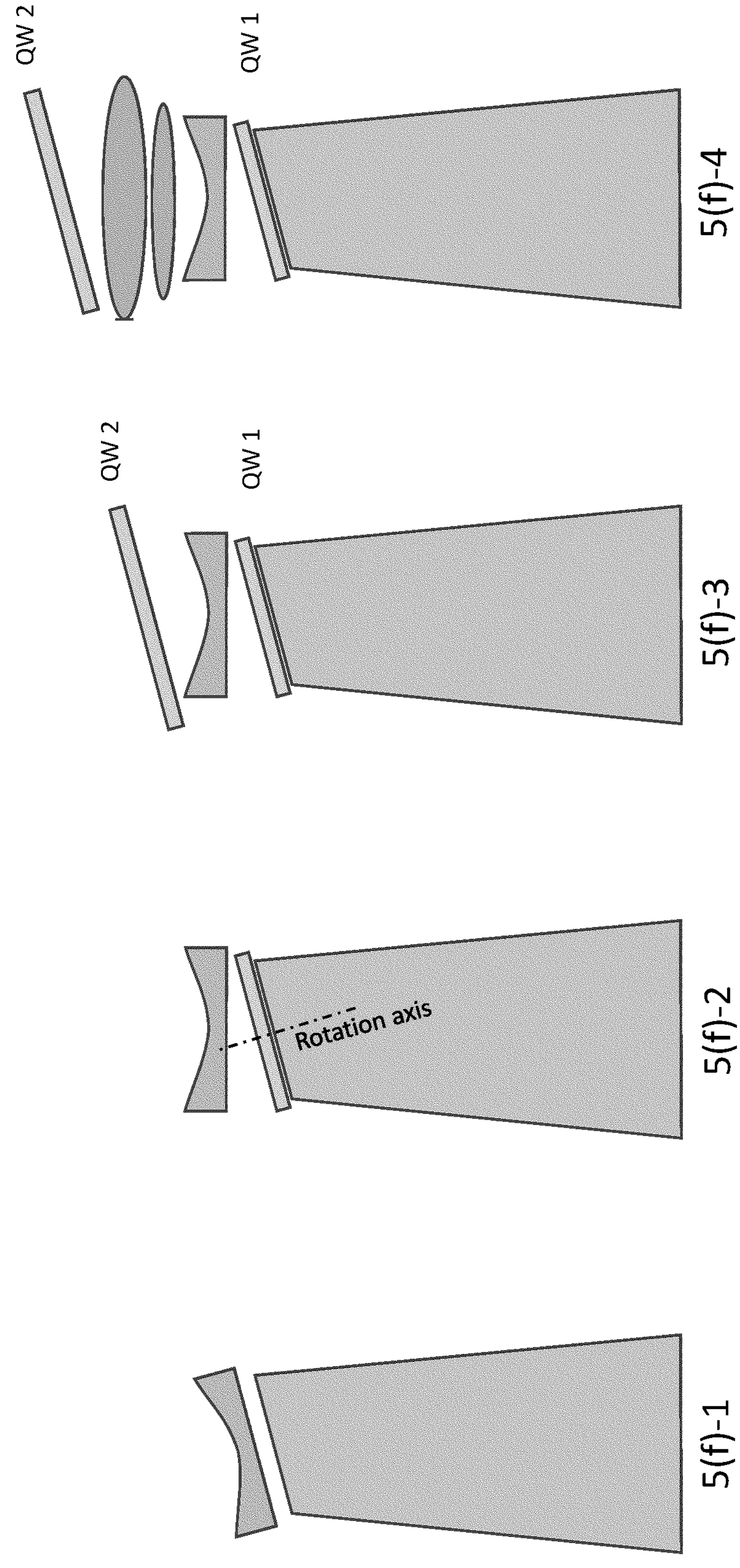

Fig. 7b

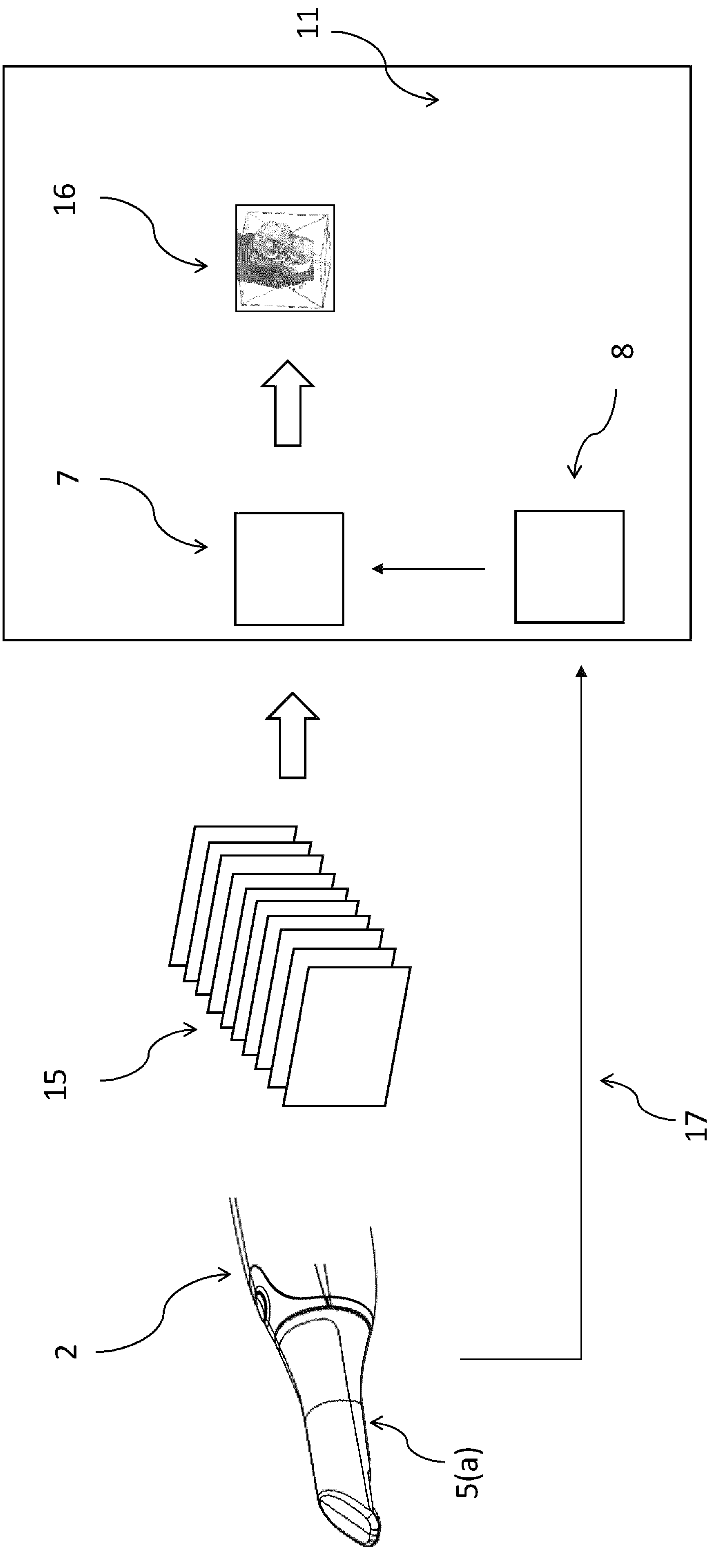

Fig. 8

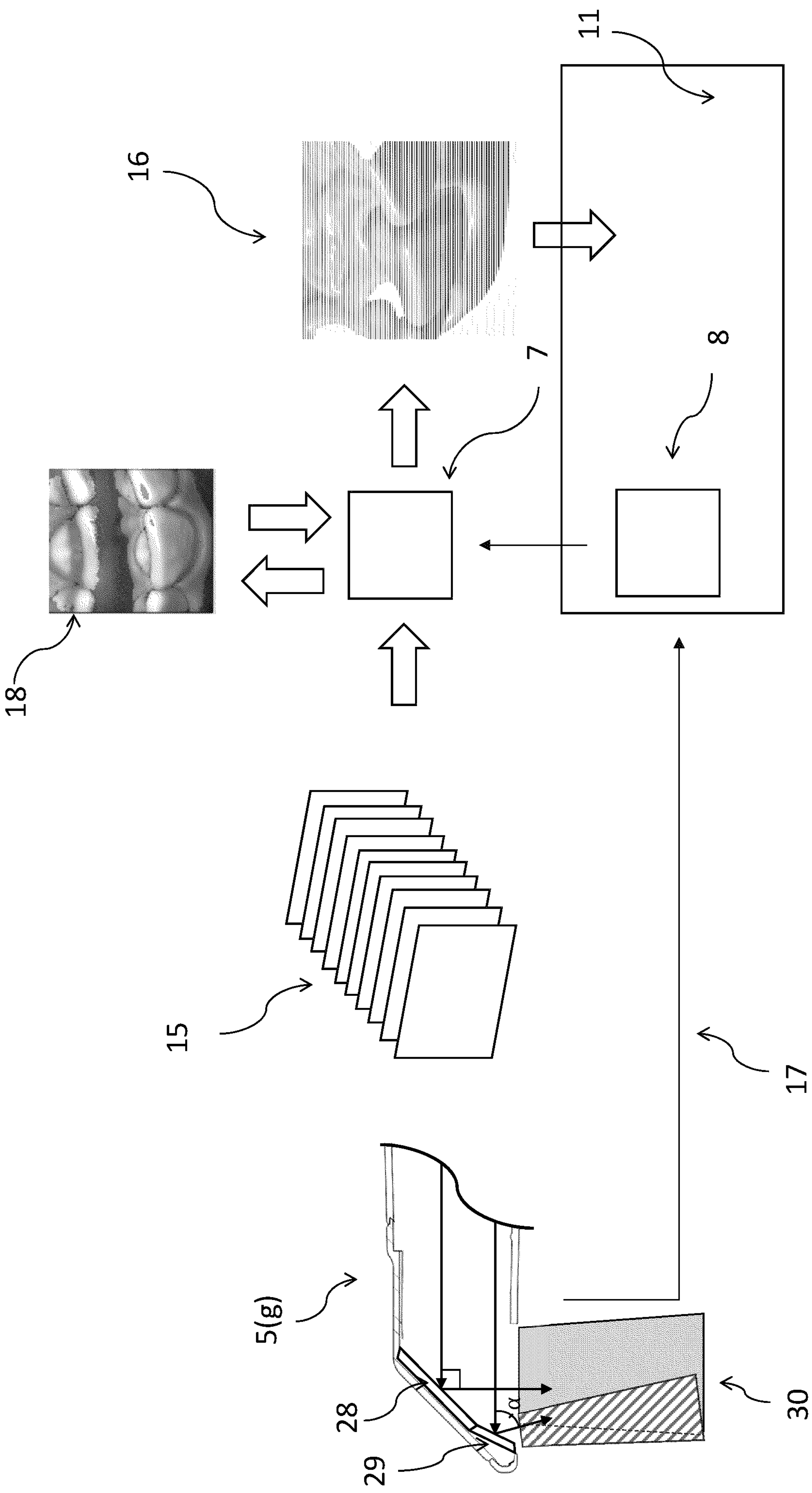

Fig. 9

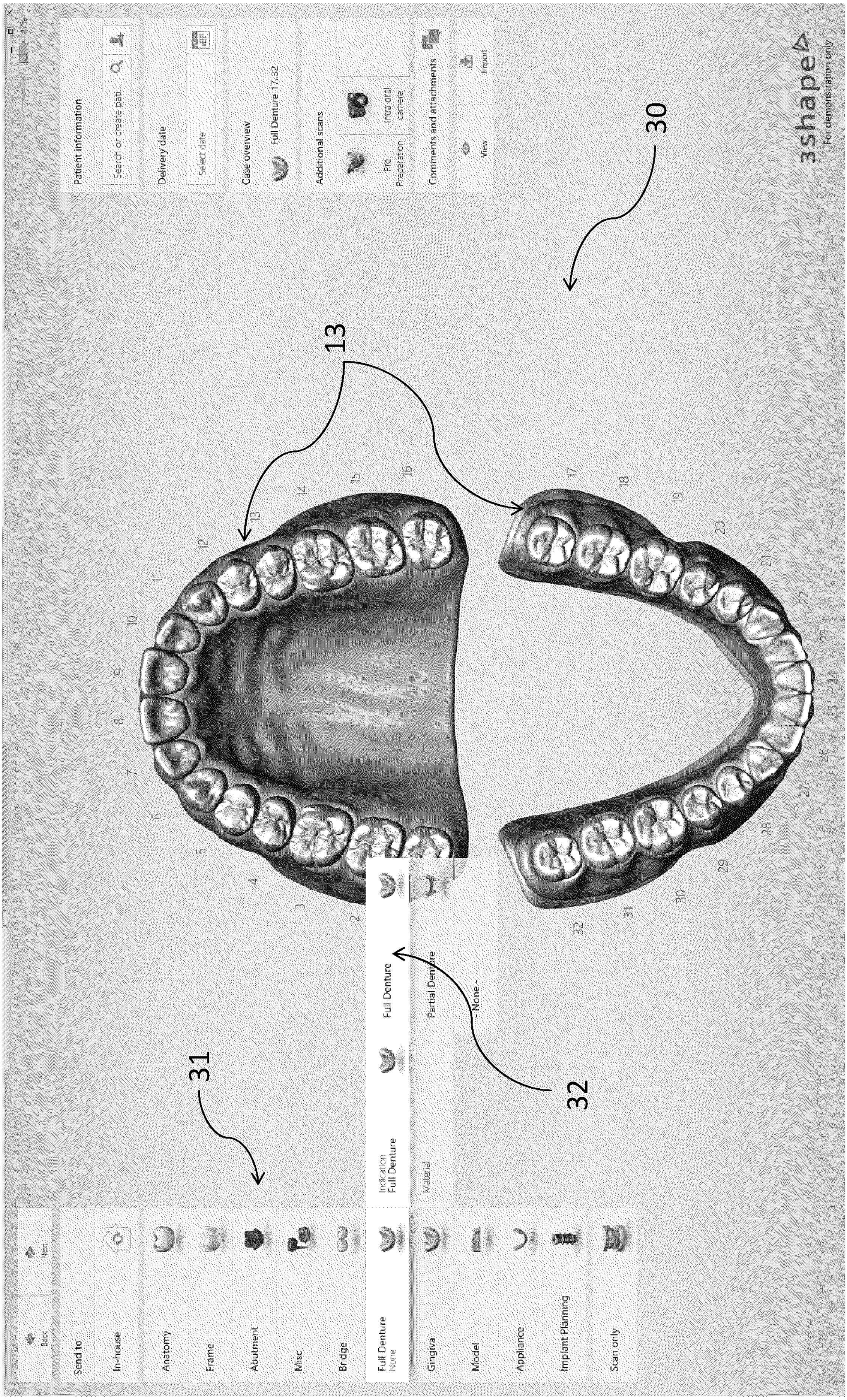
30
13
31
32
Patient information
Search or create pati...
Delivery date
Select date
Case overview
Full Denture 17.32
Additional scans
Pre-Preparation
Intra oral camera
Comments and attachments
View
Import
3shape
For demonstration only
Back
Next
Send to
In-house
Anatomy
Frame
Abutment
Misc
Bridge
Full Denture
None
Gingiva
Model
Appliance
Implant Planning
Scan only
Indication
Full Denture
Material
Full Denture
Partial Denture
- None -
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Fig. 10a

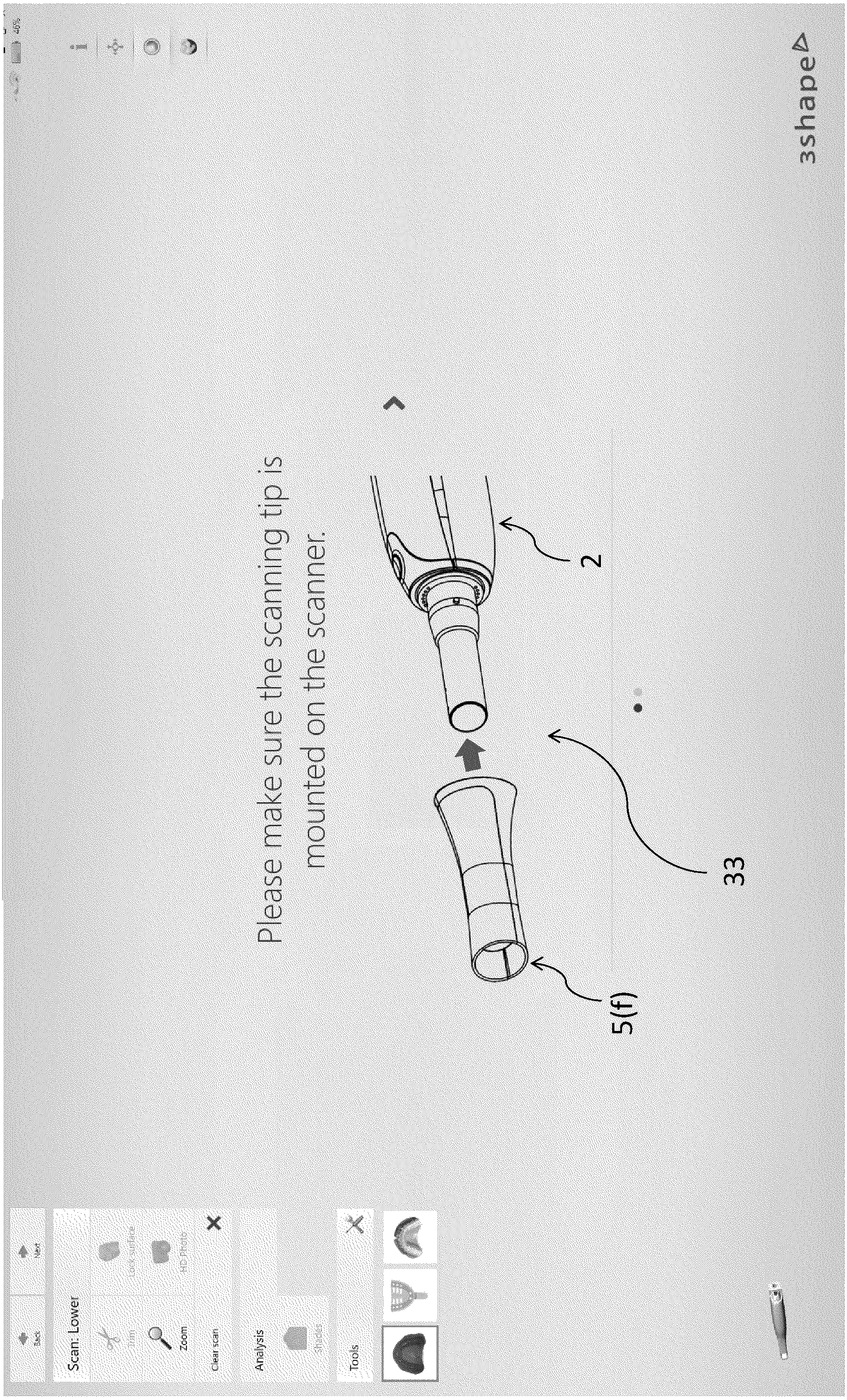
Please make sure the scanning tip is mounted on the scanner.
2
33
5(f)
3shape
Scan: Lower
Zoom
Clear scan
Analysis
Tools

Fig. 10b

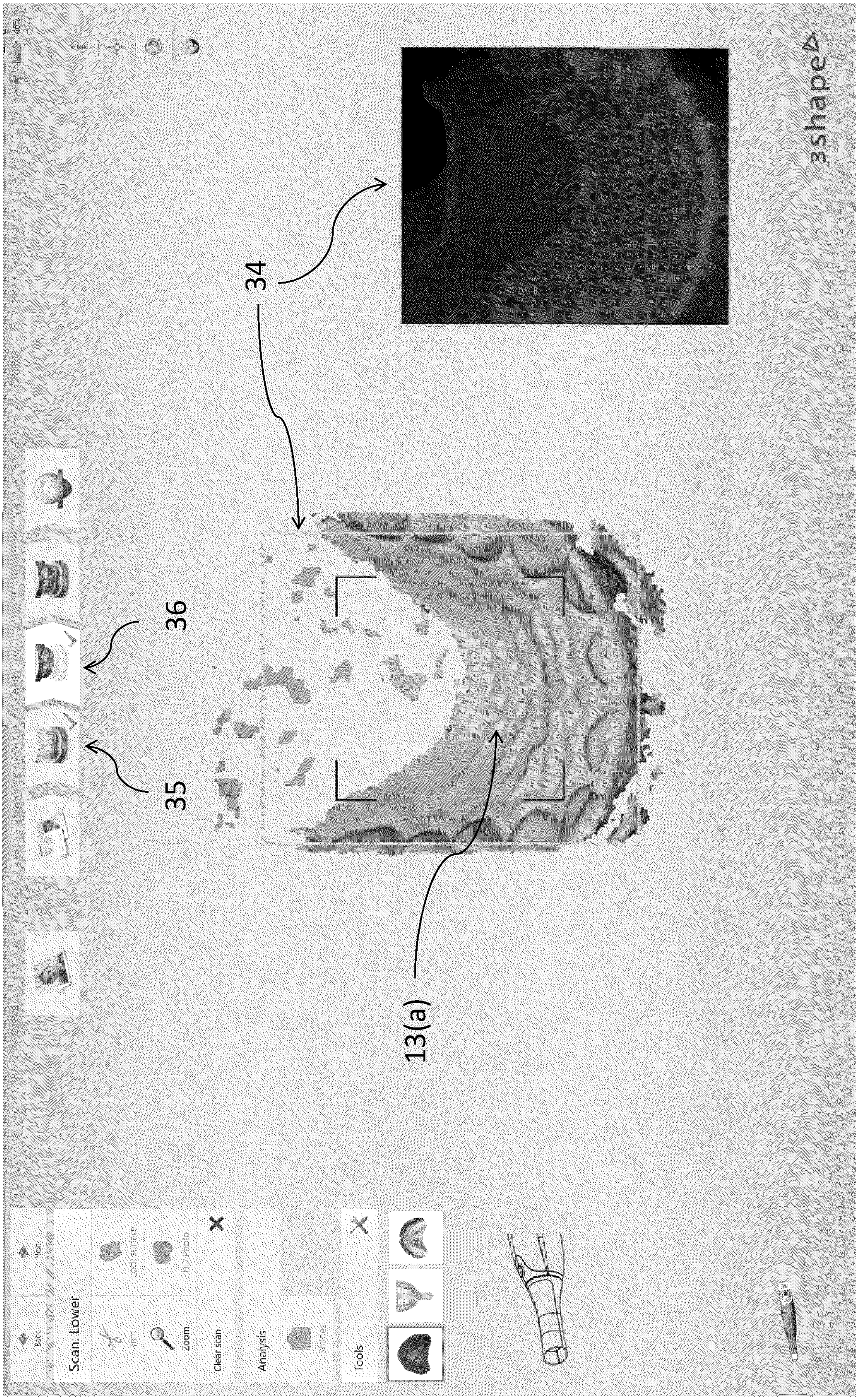
34
35
36
13(a)
Scan: Lower
Back
Next
Zoom
Clear scan
Analysis
Tools
3shape

Fig. 10c

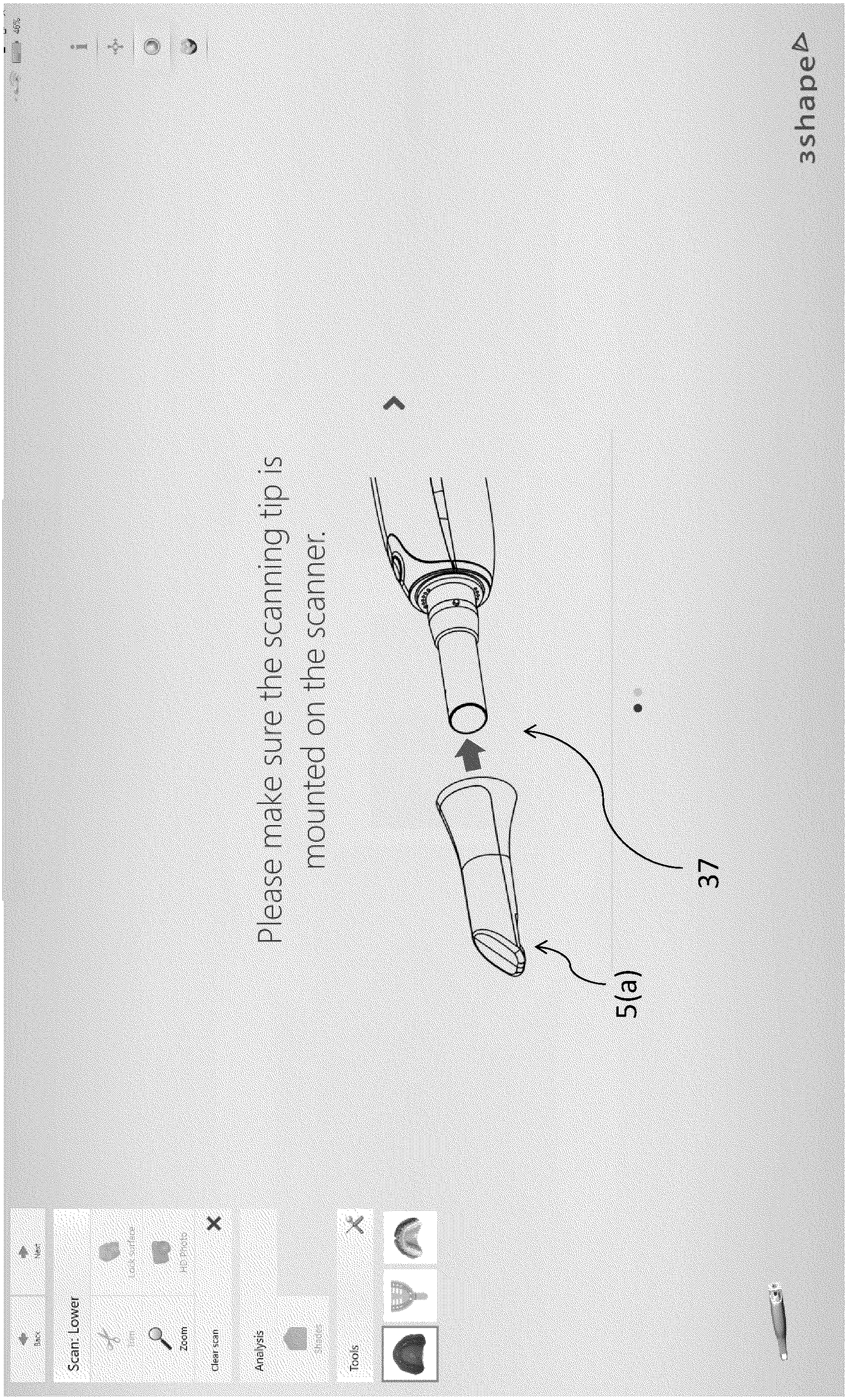
Please make sure the scanning tip is mounted on the scanner.
37
5(a)
3shape
Scan: Lower
Back
Next
Zoom
Clear scan
Analysis
Tools

Fig. 10d

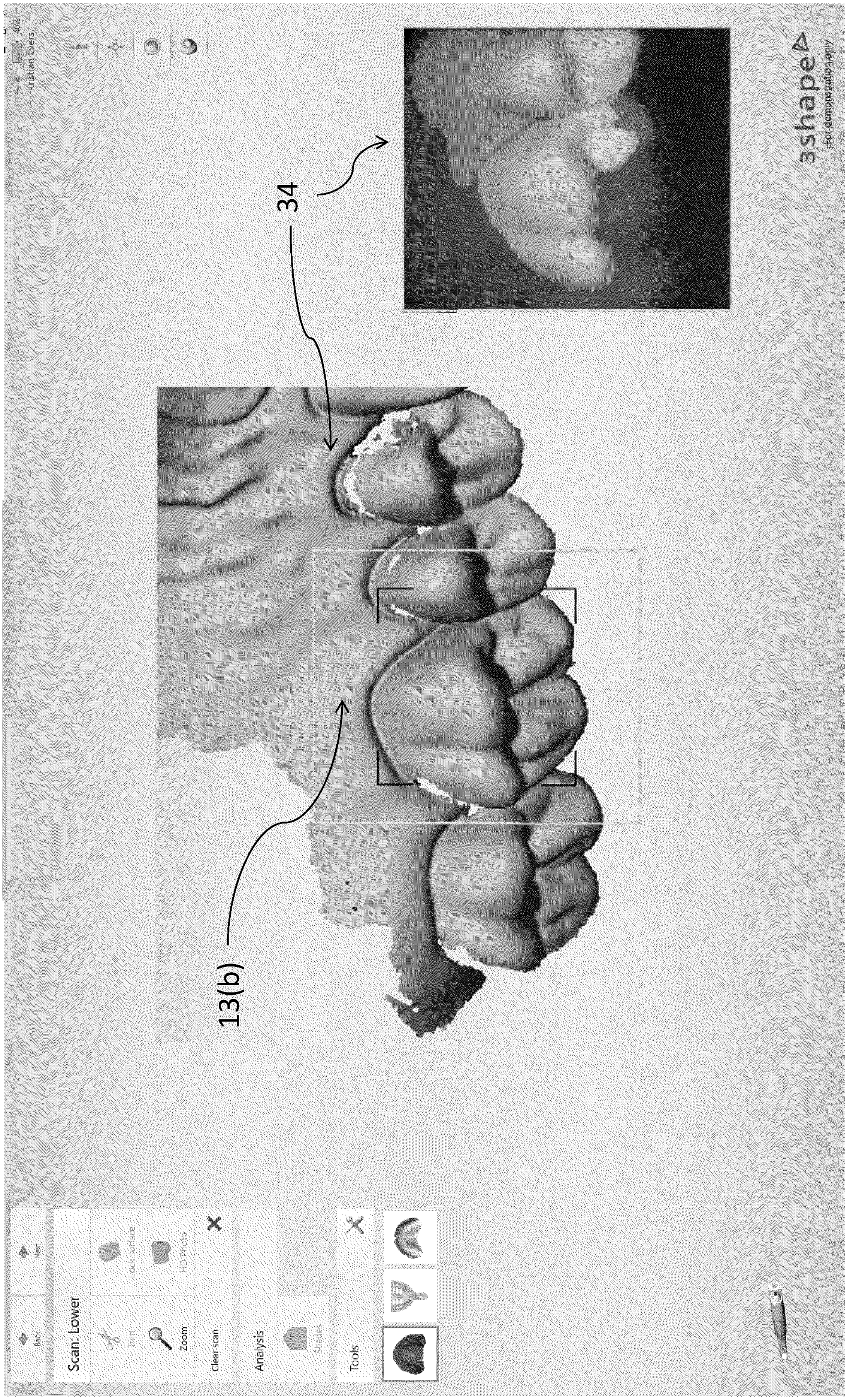
34
13(b)
Scan: Lower
Zoom
Clear scan
Analysis
Tools
Kristian Evers
3shape
For demonstration only

Fig. 10e

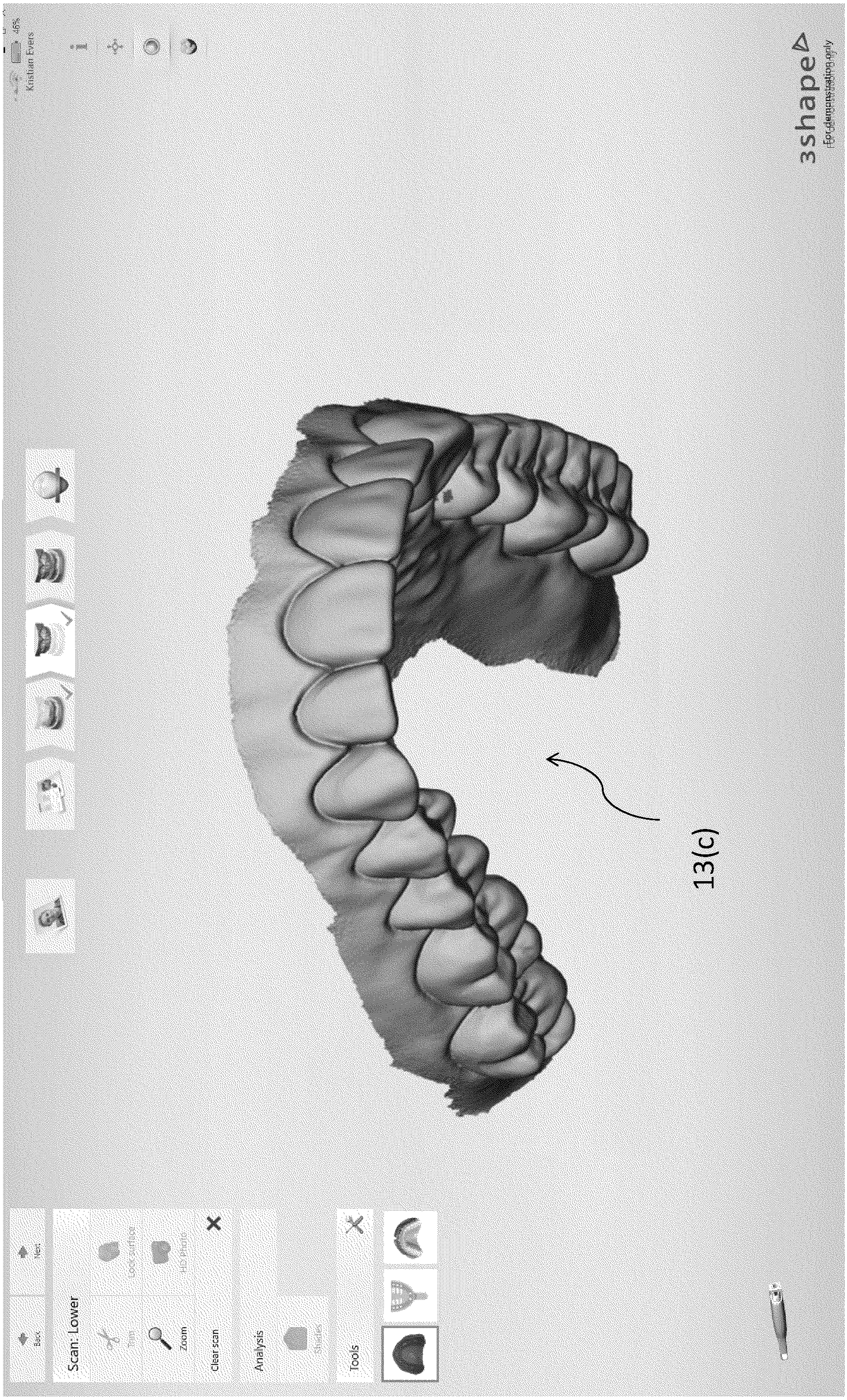
Kristian Evers
3shape
For demonstration only
Scan: Lower
Back
Next
Trim
Zoom
Clear scan
Analysis
Tools
13(c)

Fig. 10f

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/054936

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B1/00 A61C9/00 A61B5/00 A61B1/06
ADD. A61B1/247 A61B1/24 H04N5/225

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)
A61C A61B G06T

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2018/168681 A1 (J MORITA MFG CORP [JP]) 20 September 2018 (2018-09-20) abstract; figures 1,7,3 paragraphs [0012] - [0027] paragraph [0031] paragraphs [0080], [0084], [0104], [0122]	1-21
Y	WO 2018/022940 A1 (ALIGN TECHNOLOGY INC [US]) 1 February 2018 (2018-02-01) cited in the application the whole document abstract; figures 1A, 1B, 2E, 6-8,13 paragraphs [0017], [0034] - [0036] paragraphs [0065], [0093] paragraphs [0116], [0148]	1-21

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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
25 May 2020	17/06/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Thollot, Julien

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 3 121 558 A1 (J MORITA MFG CORP [JP]) 25 January 2017 (2017-01-25) abstract figures 1-4,8 paragraphs [0001], [0007] paragraphs [0054] - [0055] paragraphs [0065] - [0080]	22-30
Y	3shape: "Trios Basic Workflow", , 9 April 2014 (2014-04-09), XP055698071, youtube Retrieved from the Internet: URL:https://www.youtube.com/watch?v=-Q3e_sPFKCc [retrieved on 2020-05-25] the whole document	22-30
A	WO 2018/005009 A1 (ALIGN TECHNOLOGY INC [US]) 4 January 2018 (2018-01-04) the whole document	1-30
A	WO 2016/084066 A1 (IMAGING SOLUTIONS LTD AB [IL]) 2 June 2016 (2016-06-02) page 6, line 9 - page 8, line 17; figure 7	1-30

9

INTERNATIONAL SEARCH REPORT	International application No. PCT/EP2020/054936

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-21

   Flexible object 3D geometry and texture scanning system recognizing different replaceable scanning tips

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2. claims: 22-30

   Method for assisting a user generating an oral cavity 3D representation using a scanner with two scanning tips

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/054936

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		DE 202017007142 U1	12-02-2020
		EP 3490439 A1	05-06-2019
		EP 3578131 A1	11-12-2019
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		JP 6366546 B2	01-08-2018
		JP 2017020930 A	26-01-2017
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