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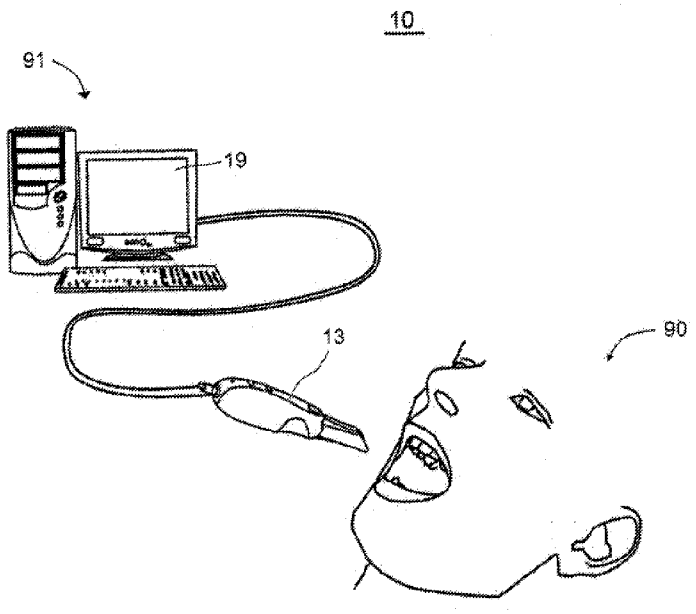


FIG. 1

(57) Abstract: A method and an apparatus of bite registration are provided. After first aligning opposing portions of an upper jaw 3D model and a lower jaw 3D model, displaying one of the first aligned jaw models where an occlusal surface of the selected first aligned jaw model is viewable. A plurality of contact points are selected on the viewable occlusal surface. Then, the 3D teeth models of the upper jaw and the lower jaw are re-aligned, where the re-alignment is based on a distance from the contact points to an occlusal surface of the opposing jaw model.

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INTERACTIVE METHOD AND SYSTEM FOR BITE ADJUSTMENT

TECHNICAL FIELD

The present disclosure generally relates to the technical field of dental 3-dimensional (3D) imaging, and in particular to a methods and/or computerized systems for bite registration.

BACKGROUND

In the dental field, it is one of key points to obtain an accurate 3D teeth model corresponding to closed or clenched state during the course of treatment (for example, orthodontics). 3D camera system is used to create a 3D model of the teeth directly with the patient, which avoids the use of cast impressions. This reduces cost and simplifies the workflow of dental restorations.

For the process of constructing global 3D teeth model, the step of bite registration is one of necessary and crucial steps. Bite registration is the process of registering the upper jaw with the lower jaw, which could establish a 3D spatial positioning relationship between an upper jaw and its corresponding, lower jaw in the closed state.

In an existing 3D camera system, during bite registration, only one bite surface is required for constructing a global 3D teeth model. In this method, the single bite surface is captured from one certain location (such as right side of molars) of the clenched teeth by a scanner, then the 3D teeth models of the upper jaw and the lower jaw captured independently are stitched onto the bite surface in a semi-automatic way so as to complete bite registration. However, when the global teeth contain a plurality of teeth (such as more than 5 teeth), the bite registration obtained from only one location of the bite surface may lead to significant mismatch in another location. For example, when only one bite surface corresponding to right side of molars is used, there are several hundred microns of mismatch in the bite registration corresponding to the distant end (such as incisors or left side of molars). Thus, it is difficult to ensure the overall accuracy of bite registration, which results that a great difference may exist between the ultimate

virtual global 3D teeth model constructed by this single bite registration and the actual global teeth in unique clenched state.

There is, then, a need for improved methods and/or computerized systems for bite registration.

SUMMARY

An aspect of this application is to advance the dental imaging art or improve the accuracy of dental bite registration.

Another aspect of this application is to address, in whole or in part, at least the foregoing and other deficiencies in the related art.

It is another aspect of this application to provide, in whole or in part, at least the advantages described herein.

Exemplary method and/or apparatus implementations according to the present disclosure can address particular needs for improved and/or more accurate bite registration. According to one aspect of the disclosure, there is provided a method of bite registration that can include obtaining 3-dimensional (3D) teeth models of opposing portions of an upper jaw and a lower jaw, first aligning the 3D teeth models of the upper jaw and the lower jaw, displaying one of the first aligned jaw models where an occlusal surface of the selected first aligned jaw model is viewable, selecting at least one contact point on the occlusal surface of the selected first aligned jaw model, second aligning the 3D teeth models of the upper jaw and the lower jaw, where the second alignment is based on a distance from the at least one selected contact point to an occlusal surface of the opposing jaw model, and displaying, transmitting, or storing the second aligned 3D models for the upper jaw and the lower jaw.

In accordance with some implementations, a device includes one or more processors, a non-transitory memory, and one or more programs; the one or more programs are stored in the non-transitory memory and configured to be executed by the one or more processors and the one or more programs include instructions for performing or causing performance of any of the methods described herein. In accordance with some implementations, a non-transitory computer readable storage medium has stored therein instructions, which, when executed by one or more processors of a device, cause the device to perform or cause performance of

any of the methods described herein. In accordance with some implementations, a device includes: one or more processors, a non-transitory memory, and means for performing or causing performance of any of the methods described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of various implementations of the invention, as illustrated in the accompanying drawings. Elements of the drawings are not necessarily to scale relative to each other.

FIG. 1 is a schematic structural view of an example system architecture to implement bite registration in accordance with some implementations.

FIG. 2 is a flowchart representation of an example method of bite registration in accordance with some implementations.

FIG. 3 is a diagram that shows an example 3D digital model of the upper jaw and an example 3D digital model of the lower jaw.

FIG. 4 is a diagram that shows an example operator interface screen for operator instructions to interactively perform a second alignment of 3D digital jaw models registration in accordance with some implementations.

FIG. 5 is a diagram that shows an example pressure occlusion map.

FIG. 6 is a diagram that shows an example re-aligned 3D digital model of the upper jaw and the 3D digital model of the lower jaw in accordance with some implementations.

FIG. 7 is a diagram that shows an example operator interface screen for operator instructions to interactively perform a second alignment of 3D digital jaw models registration in accordance with some implementations.

DESCRIPTION

Numerous details are described in order to provide a thorough understanding of the example implementations shown in the drawings. However, the drawings merely show some example aspects of the present disclosure and are

therefore not to be considered limiting. Those of ordinary skill in the art will appreciate that other effective aspects and/or variants do not include all of the specific details described herein. Moreover, well-known systems, methods, components, devices and circuits have not been described in exhaustive detail so as not to obscure more pertinent aspects of the example implementations described herein.

Where they are used, the terms “first”, “second”, and so on, do not necessarily denote any ordinal or priority relation, but may be used for more clearly distinguishing one element or time interval from another.

The term “exemplary” indicates that the description is used as an example, rather than implying that it is an ideal.

The term “in signal communication” as used in the application means that two or more devices and/or components are capable of communicating with each other via signals that travel over some type of signal path. Signal communication may be wired or wireless. The signals may be communication, power, data, or energy signals which may communicate information, power, and/or energy from a first device and/or component to a second device and/or component along a signal path between the first device and/or component and second device and/or component. The signal paths may include physical, electrical, magnetic, electromagnetic, optical, wired, and/or wireless connections between the first device and/or component and second device and/or component. The signal paths may also include additional devices and/or components between the first device and/or component and second device and/or component.

In the context of the present disclosure, the terms “viewer”, “operator”, “dentist”, “user” and the like are considered to be equivalent and refer to the viewing practitioner, technician, or other person with access to dental systems, applications, workstations and processors who views and manipulates a dental practice software to perform exemplary dental procedures including bite registration and 2D/3D images acquired, manipulated, or used in bite registration.

A “viewer instruction”, "operator instruction", or “operator command” can be obtained from explicit commands entered by the viewer or may be implicitly obtained or derived based on some other user action, such as making an

equipment setting, for example. With respect to entries entered on an operator interface, such as an interface using a display monitor and keyboard, for example, the terms “command” and “instruction” may be used interchangeably to refer to an operator entry.

The terms "3-D model", "point cloud", "3-D surface", and "mesh" may be used synonymously in the context of the present disclosure. The dense point cloud is formed using techniques familiar to those skilled in the volume imaging arts for forming a point cloud and relates generally to methods that identify, from the point cloud, vertex points corresponding to surface features. The dense point cloud is thus generated using the reconstructed contour data from one or more reflectance images. Dense point cloud information serves as the basis for a polygon model at high density for the teeth and gum surface.

FIG. 1 shows an example system architecture for bite registration in accordance with some implementations. The system 10 can be used for dental practitioner procedures including at least bite registration. As illustrated in FIG. 1, in various implementations, the system 10 includes a scanner 13 and a computerized workstation 91. The scanner 13 is handheld by the user, and the scanner 13 can be partly put into the mouth of patient 90. When put into the mouth, the scanner 13 can capture image(s) of the teeth or other 2D/3D views as necessary. The scanner 13 and the workstation 91 can be connected in a wireless or wired way so that the images, or views captured by the scanner 13 can be transmitted to the workstation for data processing or real-time displaying. Of course, some instructions generated by the workstation 91 can also be transmitted to the scanner 13 so as to control the scanner 13 operations.

The workstation 91 includes at least a monitor 19 that can display all types of 2D/3D dental practice images, user interfaces or windows, e.g., under the control of the workstation 91. Dental practice software or applications including bite registration can be installed in the workstation 91. When running some of such applications, the workstation 91 can function as an image processing device that can construct a global 3D teeth model. The workstation 91 can perform exemplary bite registration methods and/or system implementations according to this disclosure independently or coordinated with processes of constructing the

global 3D teeth model. Of course, it can be understood that the dental practice applications performed at the workstation 91 are not be limited to only these. Further, the system 10 can function alone or within a local or remote network forming a dental practice.

FIG. 2 is a flowchart representation of an example method of operating an electronic device in accordance with some implementations. In various implementations, example method 200 is performed by processing logic, including hardware, firmware, software, or a combination thereof. In some implementations, example method 200 is performed by a processor executing code stored in a non-transitory computer-readable medium (e.g., a memory). In some implementations, example method 200 is performed on a portable electronic device (e.g., laptop, tablet, smartphone).

At block 210, the method 200 obtains 3D digital models of an upper jaw and a lower jaw of a patient. For example, at block 210 the user can generate 3D digital models of the upper jaw and the lower jaw. One example method to generate the 3D digital models of the upper jaw and the lower jaw is an intraoral scan. Alternatively, at block 210 the user can access stored 3D digital models of the upper jaw and the lower jaw.

One example intraoral 3D model generation scan procedure includes the user operating the scanner 13 in the mouth of the patient 90, to capture multiple 2D images of the upper jaw and lower jaw, respectively, from each of a plurality of different viewpoints. Each set of multiple 2D images from a viewpoint can be processed to generate a single 3D view (e.g., contour image) of a portion of a jaw. Multiple 3D views from different viewpoints can be combined or stitched together to generate 3D digital teeth models of the upper and lower jaws. Such processing can be performed at the workstation 91, the scanner 13, remotely or in combination. Alternative conventional methods or system (e.g., triangulation, confocal imaging, etc.) can be used to generate the 3D digital teeth models of the upper and lower jaw.

FIG. 3 is a diagram that shows an example 3D digital model of the upper jaw 310 and an example 3D digital model of the lower jaw 320.

In various implementations, the 3D digital model of the upper jaw 310 and the 3D digital model of the lower jaw 320, can be, for example, represented by 3-D polygon mesh models in the simple form of a triangular mesh. A triangular mesh forms a basic mesh structure that can be generated from a point cloud and used as a digital model to represent a 3-D object by its approximate surface shape, in the form of triangular plane segments sharing adjacent boundaries. Methods/apparatus for forming a polygon mesh model, such as a triangular mesh or more complex mesh structure, are well known to those skilled in the contour imaging arts. The polygon unit of the mesh model, and relationships between neighboring polygons, can be used in this application to extract features (e.g., curvatures, minimum curvatures, edges, spatial relations, etc.) at the teeth boundaries.

At block 220, the method 200 performs a first bite registration or alignment of the upper jaw 3D model and the lower jaw 3D model. Since the 3D digital models of each jaw or dental arch are scanned independently, the digital models need to be related in space to represent the patient occlusion. In some implementations, the first bite registration can be a manual registration or an automatic registration.

In some implementations, at block 220 a bite surface containing a portion of the upper jaw and a corresponding portion of the lower jaw simultaneously is acquired. In some implementation, the scanner 13 is set in a location so as to capture one or more bite surfaces (e.g., 3D view or surfaces) corresponding to a portion of one or more teeth from both the upper jaw and the lower jaw. The bite surface(s) can capture a corresponding portion of the upper jaw and the lower jaw. The bite surfaces captured by the scanner 13 can be obtained in a clenched state where the upper jaw is static in relation to the lower jaw. The bite surfaces captured by the scanner 13 can be obtained in a clenched state where the upper jaw is static and completely closed in relation to the lower jaw. At block 220, for example, the bite surface is a 3D surface containing upper and lowers jaws, and in some implementations, several bite views corresponding to different teeth respectively can be used. In one example, the bite surface(s) can be displayed on the monitor 19 to the user.

It can be understood that the bite surface is a 3D surface, and usually representing a 3D shape characteristic of an outside or buccal surface of dentition. At block 220, the one or more bite surfaces can be used to automatically align the 3D teeth models of the upper jaw to the 3D teeth models of the lower jaw. In some implementations, this first alignment method is similar with that of the stitching procedure at block 210. It can also be understood that, since the teeth are rigid 3D objects, (i) the 3D model of the upper jaw can be aligned with the 3D bite surface, and (ii) the 3D model of the lower jaw can be aligned with the 3D bite surface, which aligns the 3D model of the upper jaw to the 3D model of the lower jaw. In various implementations, at least two bite surfaces from different perspective, locations around the dental arch or different teeth are used at block 220 to improve the first alignment.

Alternative conventional methods or system can be used to generate the first bite registration of the 3D digital teeth models of the upper and lower jaw at block 220. For example, physical models made from the 3D digital teeth models of the upper and lower jaw can be arranged in occlusion and scanned (e.g., digital dental x-ray imaging apparatus) to obtain relative positional information to register the upper model to the lower one.

In addition, a wax bite can be scanned and a 3D digital occlusal model generated. Then, the upper jaw model is registered to the upper side of the 3D digital occlusal model (e.g., the wax bite) and the lower jaw model is registered to the lower side of the 3D digital occlusal model. At block 220, one manual process can visually assess the upper and lower jaw models' occlusion at the workstation 91 and match their relative position in the virtual space by the user.

After block 220, the method 200 performs a second bite registration or alignment of the first aligned upper jaw 3D model and the lower jaw 3D model.

At block 230, in various implementations, the user selects one of a 3D upper jaw model 310 or a 3D lower jaw model 320. For the selected 3D jaw model, the user indicates at least one contact point. In some implementations, the user selects 3, 5, 7 or more contact points. In some implementations, the user selects or picks the contact points or contact areas by selecting the one or more contact points on user interface displaying an occlusal surface of the selected 3D

jaw model. In some implementations, the selected 3D model 310 or the 3D model 320 is presented in a display window in the user interface on display 19 in a preset orientation with the occlusal surface accessible (e.g., perspective or top view). In some implementations, the selected 3D model 310 or the 3D model 320 is presented in a display window in the user interface on display 19 with user controls to manipulate the orientation to allow access to the occlusal surface.

In one implementation, the contact points are selected through a user interface on the monitor 19. In one implementation, the contact points are selected while an example occlusion map is concurrently displayed on the monitor 19. In one implementation, the example occlusion map is a pressure occlusion map. In some implementations, the contact points are provided based on the practitioner's experiences.

FIG. 5 is a diagram that shows an example pressure occlusion map. As shown in FIG. 5, a variable pressure map 530 is illustrated in grayscale mapped to a 3D digital model of an upper jaw 510 and a 3D digital model of a lower jaw 520.

At block 240, the method 200 performs re-alignment by adjusting the 3D model of the upper jaw aligned to the 3D model of the lower jaw to provide bites with only slight intersections at the selected contact points. In some implementations, at block 240 the method reduces or optimizes a distance from the contact points to the opposite jaw. In some implementations, the method determines a transform (e.g., rotation and translation for the upper or lower jaw models) using an initial value of the first aligned bite position either from automatic or from manual bite registration (e.g., block 220).

At block 240, the method can re-adjust and accomplish the interactive post bite adjustment by determining a transform that can reduce or minimize the distance of the selected points to the opposite jaw using equation (1) below:

$$(1) \qquad \arg\min_{M} N \sum_{i=1}^{N} D\,(M \cdot x_i)$$

where M is the target transform and x_i are the selected points or points in the selected area. The function D is a metric to describe how far the selected point is from the opposite arch. In various implementations, the function D does not need to be the Euclidean distance metric but can be various kinds of distance metrics.

For example, the function D can be a signed distance function D (e.g., that depends on the local normal direction) to define a weak attracting force to assemble the jaws together and a very strong repelling force to avoid intersection.

When block 220 results in one or more captured bite surfaces, the transformation can be modified near the initial bite position using equation (2) below:

(2)

$$arg\min_{M_{bu}, M_{bl}, M} \sum_{i-1}^{N} D\,(M \cdot x_i) + \lambda_1 \sum_{i=1}^{K} (\|M_{bu}U - M_b B_i\| + \|M_{bl}L - M_b B_i\|)$$

where $\|\cdot\|$ is one kind of metric to describe the distance between the bite surface B_i and upper (U) / lower (L) arches, K is the total number of captured bites.

In addition, an amount of intersection can be controlled (e.g., decrease) by using equation (3) below:

(3)

$$arg\min_{M_{bu}, M_{bl}, M} \sum_{i-1}^{N} D\,(M \cdot x_i) + \lambda_1 \sum_{i=1}^{K} (\|M_{bu}U - M_b B_i\| + \|M_{bl}L - M_b B_i\|) + \lambda_2 \sum_{i=1}^{N_s} I\,(y_i)$$

where I is a positive function that describes the intersection amount at uniform sampled nodes y_i, and N_s is the number of the uniform sampled nodes on the arch.

At block 250, the method 200 displays the second alignment (e.g., re-alignment based on contact points) of the upper jaw 3D model and the lower jaw 3D model. In some implementations, the re-aligned or second aligned 3D models of the upper jaw and the lower jaw are shown in an occlusal relationship from a perspective viewpoint.

At block 260, the method 200 determines whether additional user modifications to the second aligned 3D models of the upper jaw and the lower jaw are desired or needed. When the determination in block 260 is negative, control passes to block 270 where the method 200 displays, transmits, or stores the second

alignment of the upper jaw 3D model and the lower jaw 3D model. When the determination in block 260 is negative, control returns to block 230.

FIG. 4 shows an example operator interface screen 460 for portions of a sequence for review and entry of contact points for a selected upper or lower jaw model. As shown in FIG. 4, operator instructions can interactively perform a second registration or alignment of the first aligned upper jaw 3D model and the lower jaw 3D model (e.g., block 230, block 240). An upper jaw or lower jaw is selected by controls 410, and the selected jaw (e.g., lower) is displayed so that the occlusal surface is viewable. In FIG. 4, an example occlusal perspective view is shown in a display area 420 of screen 460. Other view of 3D digital teeth models can be used (e.g., top view, an open mouth) so long as the selected jaw occlusal surface is viewable. In one implementation, a series of preset selectable occlusal orientations can be sequential viewed. Contact points are then added by the user to the selected displayed 3D jaw model. Operator controls 430 provide entry actions for contact points 430a. As shown in FIG. 4, using operator controls 430, the user can select up to five contact points and place them at designated positions on the selected occlusal surface. Additional contact points can be requested. Further, all contact points 430a can be cleared with a single "clear" operator action. An occlusal pressure map 530 or the like can be displayed in correspondence as an aid to the user. In some implementations, a collision or contact value of the occlusal pressure map 530 or the like can be mapped to the selected jaw model. In some implementations, an optional depth of intersection at the contact points 430a can be preset or individually set. As shown in FIG. 4, operator controls 440 provide entry actions for a depth of the intersection at the contact points 430. The depth of the intersection can be variable, e.g., 50, 100, 150 or 200 microns, by contact point. In some implementations, the depth of the intersection can vary by dental lab, dental clinic or practitioner. Alternatively, the depth of the intersection can vary by tooth type or distance from the first alignment bite surface.

Operator controls 450 provide operator entry actions to view the first aligned jaw models or the second aligned jaw models. FIG. 6 is a diagram that shows an example perspective view of the re-aligned 3D digital model of the upper jaw and the 3D digital model of the lower jaw. As shown in FIG. 6, the

underlying 3D digital model of the upper jaw 310 and 3D digital model of the lower jaw 320 can optionally be shown with second re-aligned jaw models 610. Operator controls 470 provide operator entry actions to store the second aligned 3D jaw models.

In various implementations, the user can compare results against the first alignment and easily adjust parameters to view results of successive second alignment attempts.

FIG. 7 shows an example operator interface screen 760 for portions of a sequence for review and entry of contact points for a selected upper or lower jaw model registration in accordance with some implementations. As shown in FIG. 7, operator instructions can interactively perform a second registration or re-alignment of the first aligned upper jaw 3D model and the lower jaw 3D model (e.g., block 230, block 240). Operator control 705 can be used to enter or exit the bite adjustment interface 760. As shown in FIG. 7, a 3D digital model of the upper jaw 710 and 3D digital model of the lower jaw 720 are shown in a left display 720A, and operator control 730 allows operator actions to enter contact points 730a on the visible occlusal surface of both jaws. Operator control 740 can be used to undo a last picked contact point, and operator control 750 can be clear all contact points. Operator control 770 can be used to apply the selected contact points, and the resulting second aligned bite adjustment result 780 is illustrated on a right display 720B (right half) on the screen 760. When the second aligned bite adjustment result 780 is shown, the selected contact points 730a can be shown in both the left display 720A and the right display 720B.

Consistent with one implementation, the present disclosure can use a computer program with stored instructions that control system functions for image acquisition and image data processing for image data that is stored and accessed from an electronic memory. As can be appreciated by those skilled in the image processing arts, a computer program of an implementation of the present invention can be utilized by a suitable, general-purpose computer system, such as a personal computer or workstation that acts as an image processor, when provided with a suitable software program so that the processor operates to acquire, process, transmit, store, and display data as described herein. Many other types of

computer systems architectures can be used to execute the computer program of the present invention, including an arrangement of networked processors, for example.

The computer program for performing the method of the present invention may be stored in a computer readable storage medium. This medium may comprise, for example; magnetic storage media such as a magnetic disk such as a hard drive or removable device or magnetic tape; optical storage media such as an optical disc, optical tape, or machine readable optical encoding; solid state electronic storage devices such as random access memory (RAM), or read only memory (ROM); or any other physical device or medium employed to store a computer program. The computer program for performing the method of the present invention may also be stored on computer readable storage medium that is connected to the image processor by way of the internet or other network or communication medium. Those skilled in the image data processing arts will further readily recognize that the equivalent of such a computer program product may also be constructed in hardware.

It is noted that the term "memory", equivalent to "computer-accessible memory" in the context of the present disclosure, can refer to any type of temporary or more enduring data storage workspace used for storing and operating upon image data and accessible to a computer system, including a database. The memory could be non-volatile, using, for example, a long-term storage medium such as magnetic or optical storage. Alternately, the memory could be of a more volatile nature, using an electronic circuit, such as random-access memory (RAM) that is used as a temporary buffer or workspace by a microprocessor or other control logic processor device. Display data, for example, is typically stored in a temporary storage buffer that is directly associated with a display device and is periodically refreshed as needed in order to provide displayed data. This temporary storage buffer can also be considered to be a memory, as the term is used in the present disclosure. Memory is also used as the data workspace for executing and storing intermediate and final results of calculations and other processing. Computer-accessible memory can be volatile, non-volatile, or a hybrid combination of volatile and non-volatile types.

It is understood that the computer program product of the present disclosure may make use of various image manipulation algorithms and processes that are well known. It will be further understood that the computer program product implementation of the present invention may embody algorithms and processes not specifically shown or described herein that are useful for implementation. Such algorithms and processes may include conventional utilities that are within the ordinary skill of the image processing arts. Additional aspects of such algorithms and systems, and hardware and/or software for producing and otherwise processing the images or co-operating with the computer program product of the present invention, are not specifically shown or described herein and may be selected from such algorithms, systems, hardware, components and elements known in the art.

In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the terms "including" and "comprising" are open-ended, that is, a system, device, article, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim.

Exemplary implementations according to the application can include various features described herein (individually or in combination).

While the invention has been illustrated with respect to one or more implementations, alterations and/or modifications can be made to the illustrated examples without departing from the spirit and scope of the appended claims. The presently disclosed implementations are therefore considered in all respects to be illustrative and not restrictive. In addition, while a particular feature of the invention can have been disclosed with respect to one of several implementations, such feature can be combined with one or more other features of the other implementations as can be desired and advantageous for any given or particular

function. The term “at least one of” is used to mean one or more of the listed items can be selected. The term “about” indicates that the value listed can be somewhat altered, as long as the alteration does not result in nonconformance of the process or structure to the illustrated implementation. Other implementations of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims, and all changes that come within the meaning and range of equivalents thereof are intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A method of bite registration, comprising:

obtaining 3-dimensional (3D) teeth models of opposing portions of an upper jaw and a lower jaw;

first aligning the 3D teeth models of the upper jaw and the lower jaw;

selecting one of the first aligned jaw models where an occlusal surface of the selected first aligned jaw model is viewable;

selecting at least one contact point on the occlusal surface of the selected first aligned jaw model;

second aligning the 3D teeth models of the upper jaw and the lower jaw, where the second alignment is based on a distance from the at least one selected contact point to an occlusal surface of the opposing jaw model; and

displaying, transmitting, or storing the second aligned 3D models for the upper jaw and the lower jaw.

2. The method of claim 1, where the second aligning is further based on an intersection depth for each contact point.

3. The method of claim 2, where the intersection depth for the at least one contact point is a user selected intersection depth.

4. The method of claim 3, where the first aligning is automatic or manually performed.

5. The method of claim 1, where the first aligning comprises (i) obtaining at least one bite surface image or model containing a portion of a tooth of the upper jaw and a portion of an opposing tooth of the lower jaw simultaneously in a clenched state where the upper jaw is static relative to the lower jaw), (ii) obtaining at least one physical bite plate or model, or (iii) obtaining a plurality of manual actions.

6. The method of claim 5, where the at least one bite surface image or model is 3D.

7. The method of claim 1, further comprising manipulating the selected first aligned jaw model to provide a top view or a perspective view of the occlusal surface, where the selected first aligned jaw model comprises a plurality of teeth.

8. The method of claim 1, where selecting at least one contact point on the occlusal surface of the selected first aligned jaw model comprises:

selecting three or more contact points on the occlusal surface of the selected first aligned jaw model; and

selecting an intersection depth for each of the three or more contact points.

9. The method of claim 8, where the intersection depth is different for at least two of the three or more contact points.

10. The method of claim 9, where the intersection depth is different based on a lab or practitioner.

11. The method of claim 1, where obtaining 3-dimensional (3D) teeth models of opposing portions of an upper jaw and a lower jaw comprises:

performing a first intraoral scan of a plurality of teeth of the upper jaw with a scanner to generate a 3D digital model; and

performing a second intraoral scan of a plurality of teeth of the lower jaw with the scanner to generate a 3D digital model; and

12. A system of bite registration, comprising:

means for obtaining 3-dimensional (3D) teeth models of opposing portions of an upper jaw and a lower jaw;

means for first aligning the 3D teeth models of the upper jaw and the lower jaw;

means for selecting one of the first aligned jaw models, where an occlusal surface of the selected first aligned jaw model is viewable;

means for selecting three or more contact points on the occlusal surface of the selected first aligned jaw model;

means for second aligning the 3D teeth models of the upper jaw and the lower jaw, where the second alignment is based on a distance from the at least one selected contact point to an occlusal surface of the opposing jaw model; and

means for displaying, transmitting, or storing the second aligned 3D models for the upper jaw and the lower jaw.

13. The system of claim 12, where the means for selecting contact points provides an intersection depth for each of the contact points, where the means for second aligning uses the intersection depth for said each contact point.

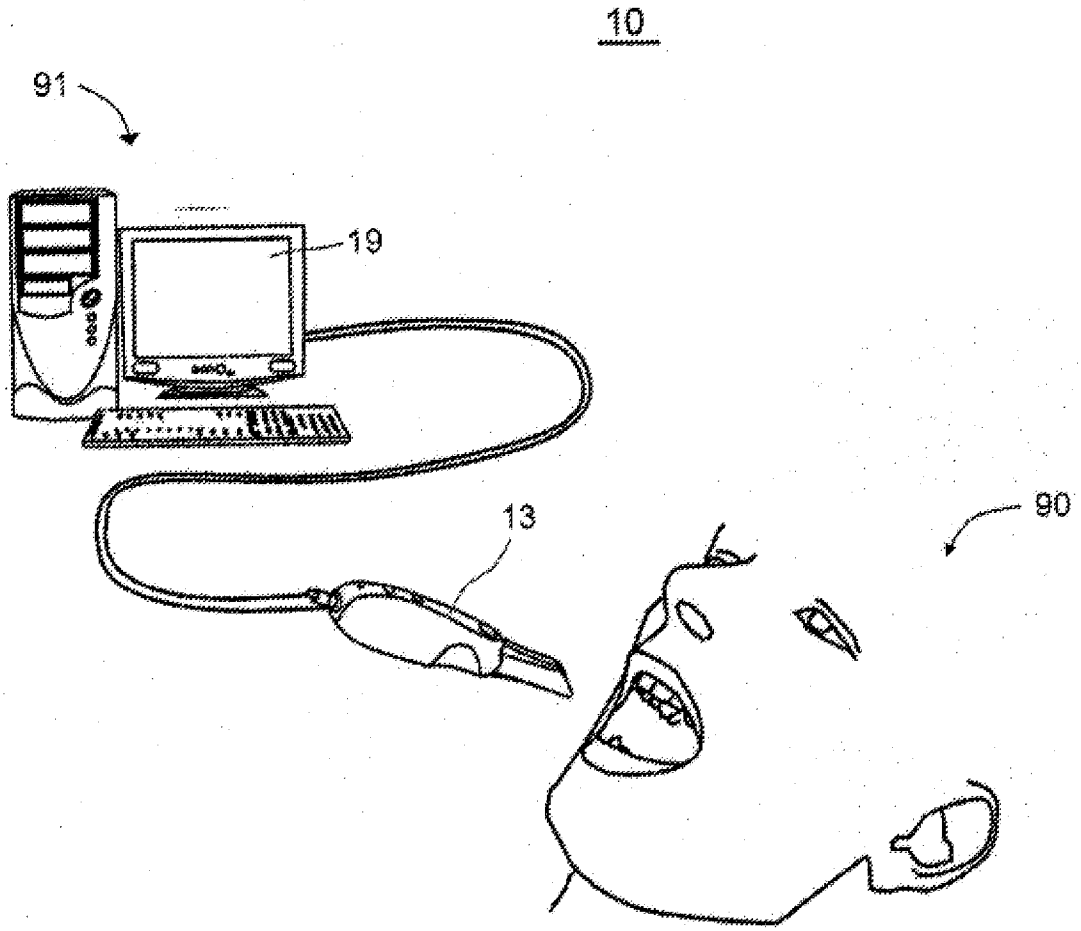


FIG. 1

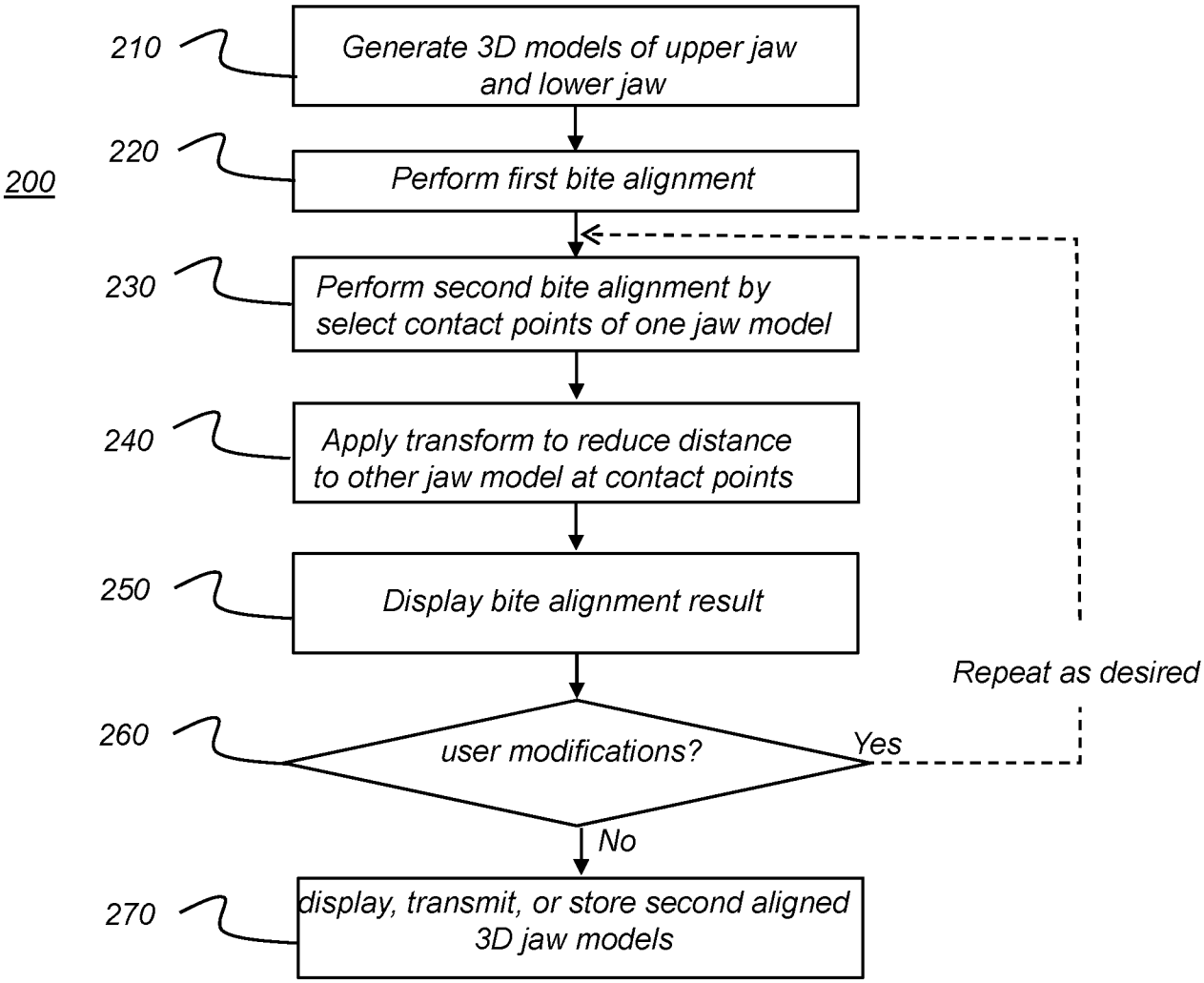

200
210
Generate 3D models of upper jaw and lower jaw
220
Perform first bite alignment
230
Perform second bite alignment by select contact points of one jaw model
240
Apply transform to reduce distance to other jaw model at contact points
250
Display bite alignment result
260
user modifications?
Yes
Repeat as desired
No
270
display, transmit, or store second aligned 3D jaw models

FIG. 2

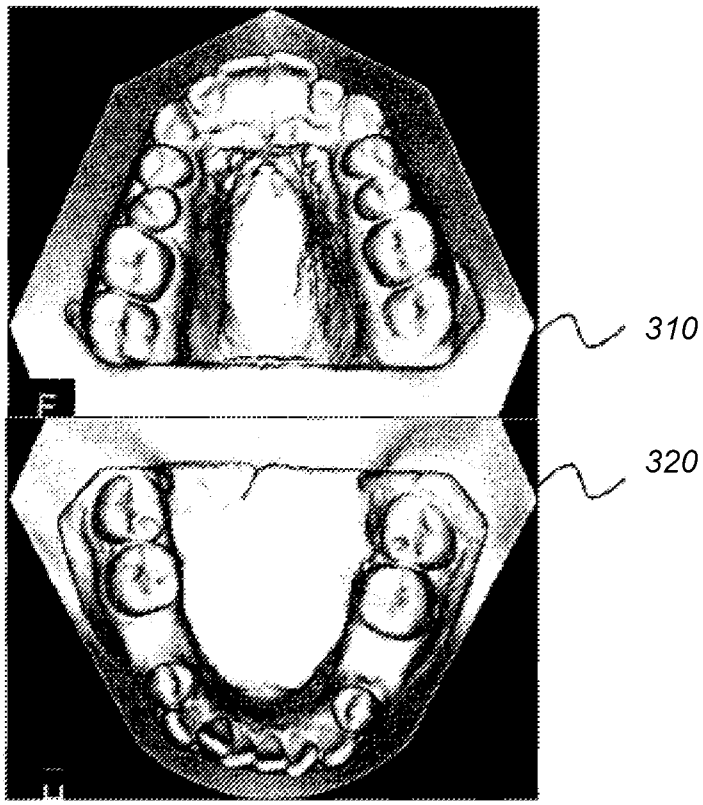


FIG. 3

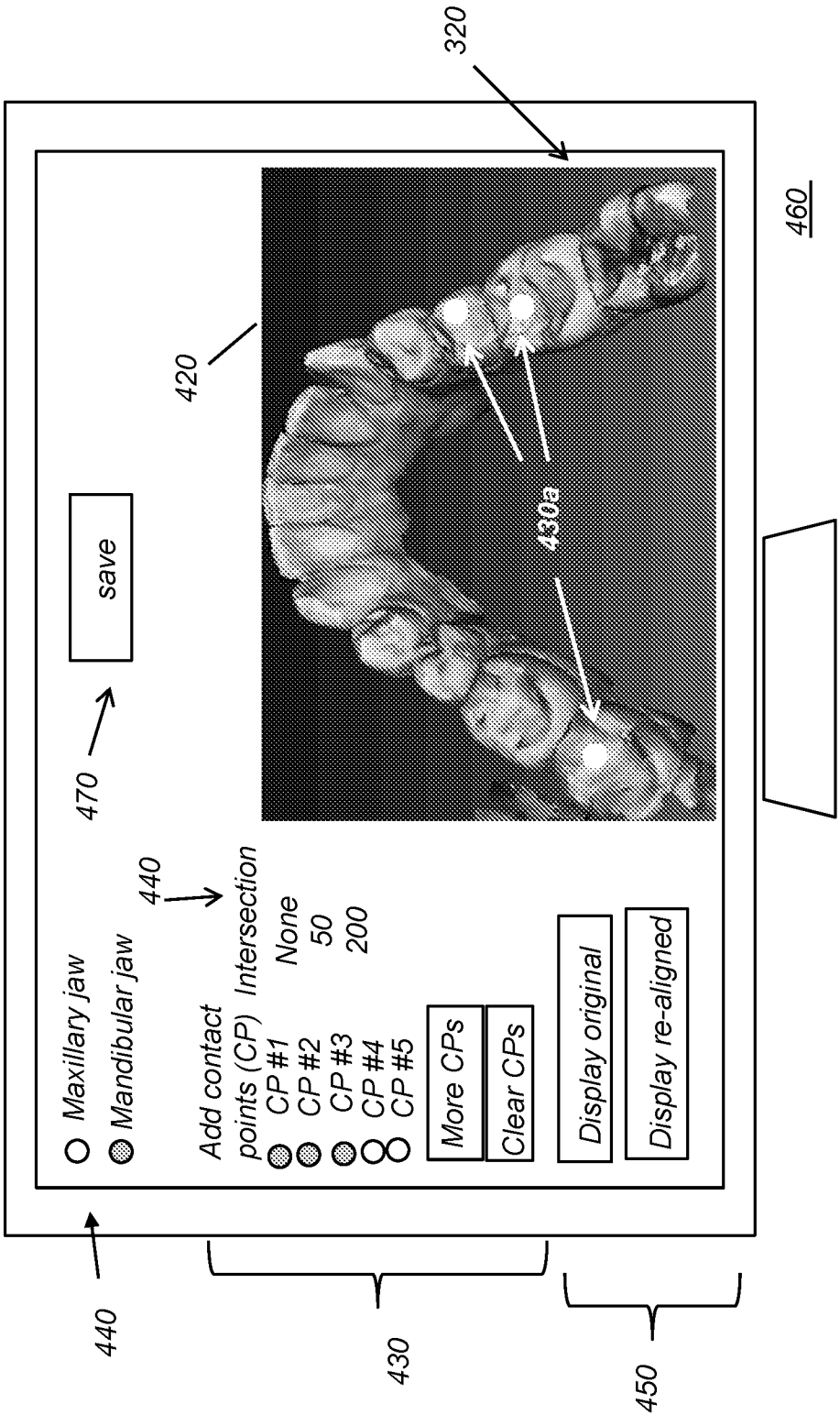

320
420
460
save
470
440
Maxillary jaw
Mandibular jaw
Add contact points (CP)
Intersection
CP #1
None
CP #2
50
CP #3
200
CP #4
CP #5
More CPs
Clear CPs
Display original
Display re-aligned
430a
440
430
450

FIG. 4

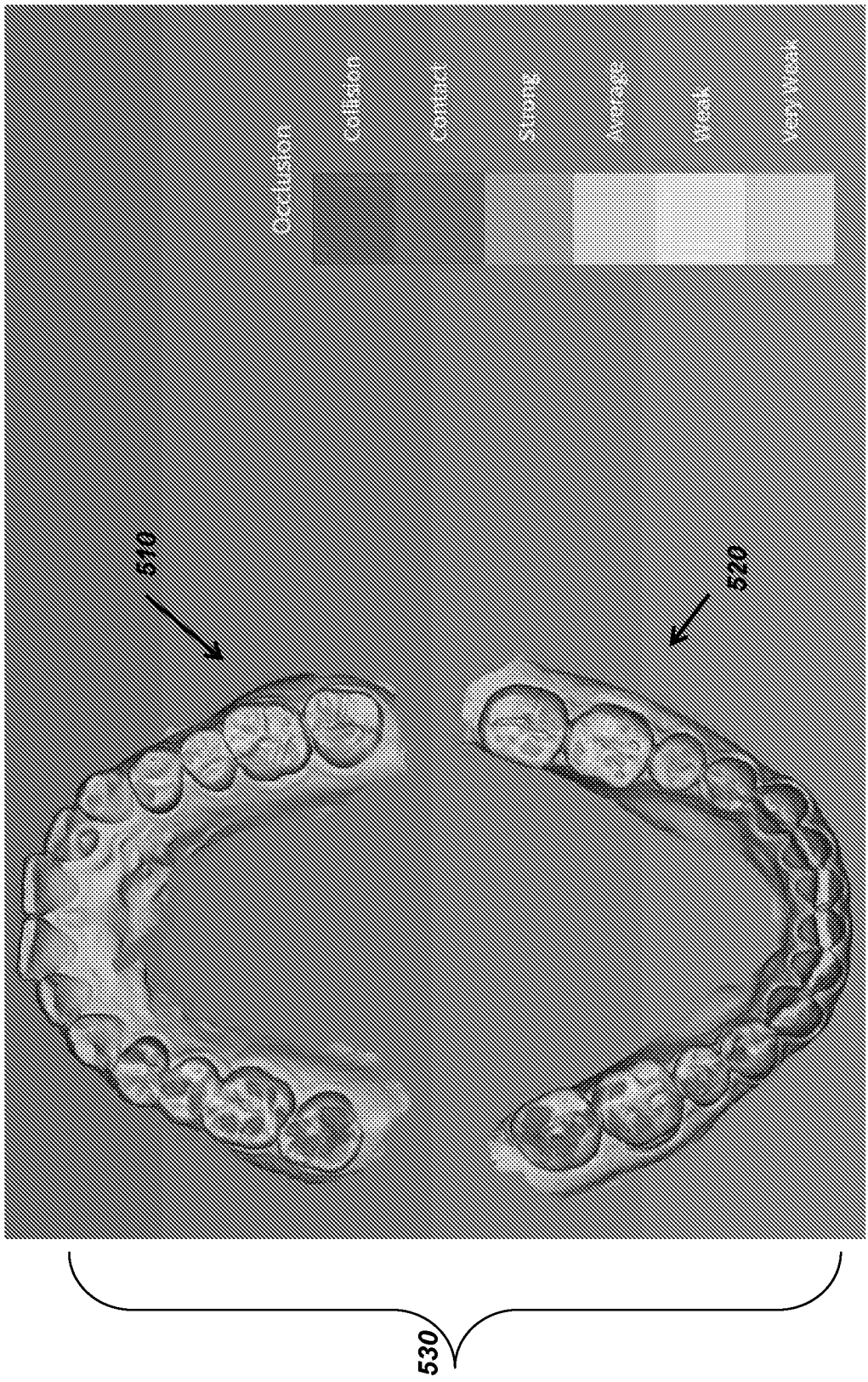

Cohesion
Adhesion
Content
Strength
Adhesion
Weak
Very Weak
510
520
530

FIG. 5

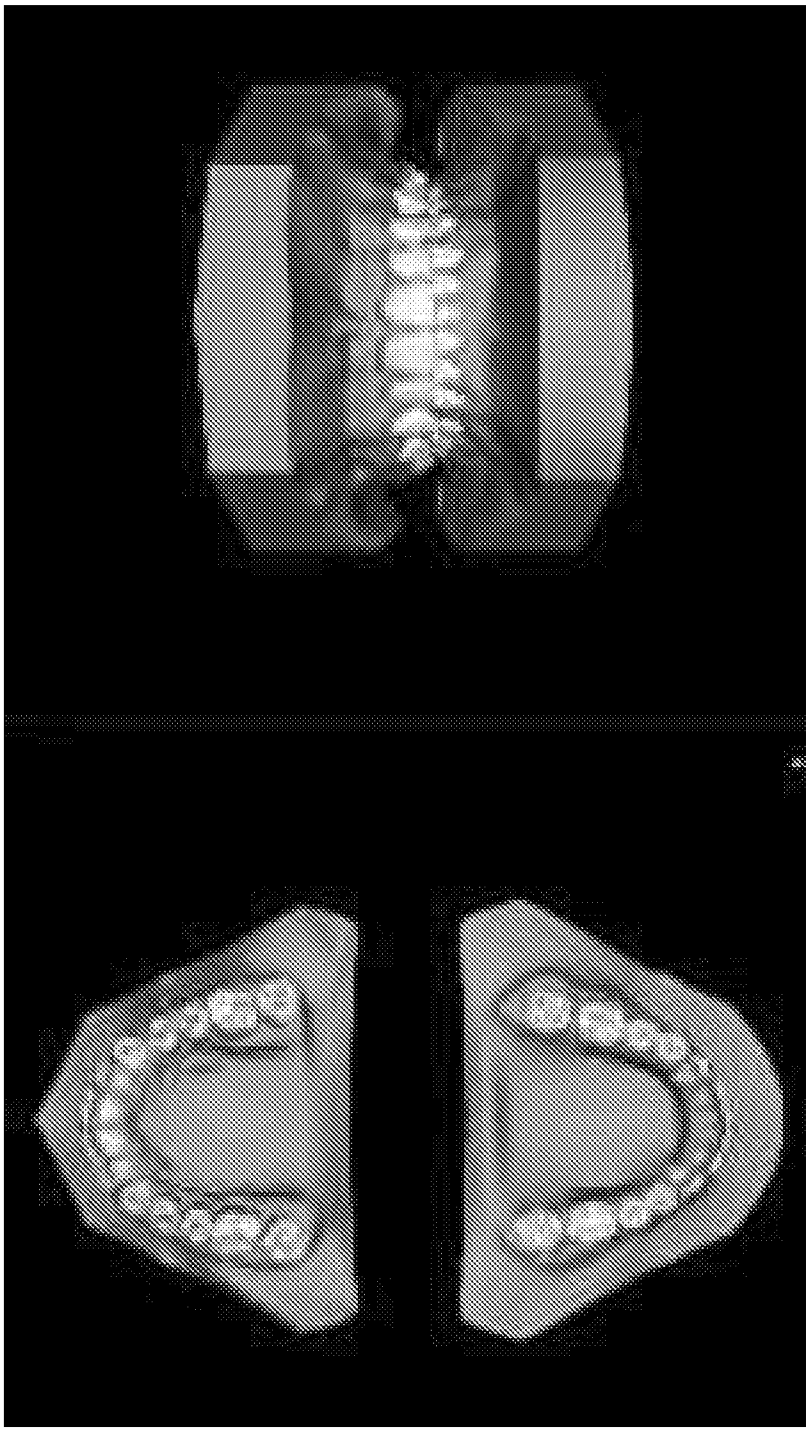


FIG. 6

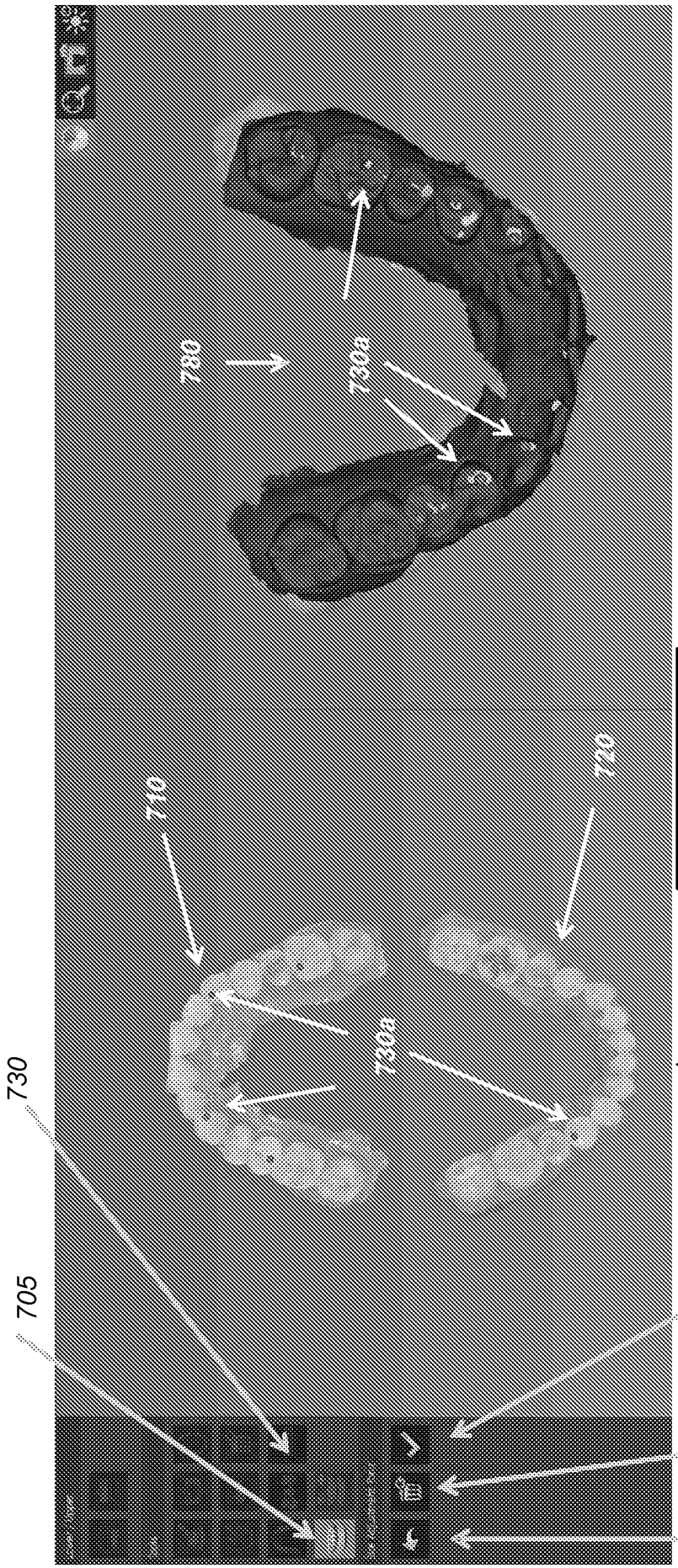


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/101936

A. CLASSIFICATION OF SUBJECT MATTER

A61C 19/05(2006.01)i

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

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)

CNKI, CNPAT, WPI, EPODOC, IEEE: bite, registration, 3D, jaw, upper, lower, align, teeth, tooth, contact w point, distance

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016008116 A1 (CARESTREAM HEALTH, INC.) 14 January 2016 (2016-01-14) description, paragraphs [0003], [0053], [0056], [0058], [0070], claim 1	1-13
A	WO 2006085851 A1 (DENTSPLY INTERNATIONAL INC.) 17 August 2006 (2006-08-17) the whole document	1-13
A	US 2002094509 A1 (DURBIN, DUANE ET AL.) 18 July 2002 (2002-07-18) the whole document	1-13

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 May 2019	**22 May 2019**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing** **100088** **China**	**DONG,Gang**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53961348**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/101936

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2016008116	A1	18 September 2014	KR	20150128713	A	18 November 2015
				JP	2016508860	A	24 March 2016
				EP	2967784	A1	20 January 2016
				WO	2014139078	A1	18 September 2014
				CN	105007856	A	28 October 2015
WO	2006085851	A1	17 August 2006	US	2005153257	A1	14 July 2005
				EP	1845889	A1	24 October 2007
US	2002094509	A1	18 July 2002	None			