THREE-DIMENSIONAL ORAL IMAGING SYSTEM AND METHOD

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

Not Applicable.

FIELD OF INVENTION

Embodiments of the present invention relate to the field of oral scanning, and relate more specifically to a system and method for using a dental tray device for intraoral and extraoral scanning.

BACKGROUND OF DISCLOSURE

Numerous processes for acquiring dental impressions have been implemented for the purpose of creating comfortably-fitting, functional, and cosmetically appealing dental restorations. Information acquired by such processes are typically used for careful planning of dental surgeries as well as for gaining a better understanding of orthodontic movements. Analog techniques typically involve taking an impression using an elastic material; however, these techniques bear the disadvantages of ~~substantial~~increased discomfort to the user and increased procedure time. Digital intraoral scanning (IOS) techniques offer many benefits over traditional, analog techniques, including the ability to acquire three-dimensional (3D) digital impressions ~~through imaging~~ with a higher degree of accuracy, greater strength and comfort to the user. The 3D digital impressions can then be manufactured through reverse engineering procedures by means of computer-aided design (CAD) and computer assisted manufacturing (CAM) systems.

Two common types of digital IOS devices that have been implemented are scanner wands and benchtop scanners. Scanner wands offer a compact and light-weight method for acquiring 3D images but with many inherent disadvantages, such as errors in the resulting 3D

images due to movement between the source and target, or discomfort to the person being scanned. Benchtop scanners are a bulky alternative to scanner wands and typically consist of two cameras or sensors attached to a rotating mechanism where the objects being scanned are rotated on several axes so that the scanner can accurately capture details from several perspectives. Several alternative intraoral devices have been described that attempt to overcome the issues presented by scanner wands and benchtop scanners. These devices, however, frequently exhibit other notable problems, such as difficulty in detecting deep margin lines in prepared teeth or in the case of bleeding, problems arising from condensation of water on the lenses. There exists a need for a lightweight, compact digital IOS device and method capable of acquiring high resolution 3D images of the teeth, lips, and gums in a timely manner and with minimal discomfort.

SUMMARY OF THE DISCLOSURE

The present invention provides an oral imaging system and method for scanning the interior and exterior regions of a mouth. In a preferred embodiment, the oral imaging system comprises a dental tray having one or more imaging strips positioned on the various surfaces of the dental tray. Each imaging strip has an illumination strip extending along the length of the imaging strip for providing light to the region of the mouth being scanned. Each imaging strip is also equipped with one or more imaging sensors for acquiring images of the region of the mouth being scanned, each imaging sensor being positioned in proximity to and along the illumination strip in a configuration that may be either expanded or condensed and may be either matched or alternating. In matched configurations, the imaging sensors are positioned on both sides of a respective illumination strip and directly across from one another. In alternating configurations, the imaging sensors are positioned on both sides of a respective illumination strip diagonally across from one another.

It is a feature of the present invention that suction channels or blow channels positioned in proximity to the imaging sensors along the edge of the imaging strip significantly reduce the amount of water that condenses on or stays condensed on the imaging sensors while the dental tray is inside a mouth.

It is a feature of the present invention to integrate technology such as ~~ultra-wide angle lenses,~~ time of flight cameras, one or more polarizing lenses for imaging sensors used herein,

or similar functionality to reduce the need for powders that reduce the reflectivity of teeth when taking a dental impression.

It is a feature of the present invention that an extraoral extension be reversibly attachable to the handle of the dental tray so that the exterior regions of the lips may also be scanned at the same time as the interior regions of the mouth.

It is a feature of the present invention that two embodied dental trays may be used in a stacked configuration to scan the entire oral region of a user at one time. It is a further feature of the present invention that for embodiments having two dental trays in a stacked configuration, a detachable triangular ramp placed in the fitting surface of the lower, or mandibular tray compartment allows for the efficient and effective placement, positioning, and directing of the lower jaw and associated condyles toward the Centric Relation (CR), a repeatable and reliable position used in recording the jaw relations. Furthermore, it is a feature of the present invention that excursive movement data may be acquired by placing accelerometers or other relational data sensors on the dental trays and any teeth, gums, or dental structures, moving the lower jaw in opening and closing and to left and right relative to the initial jaw position, capturing multiple images, and comparing relational data.

It is a feature of the present invention that, during operation of the oral imaging system, the position and orientation of the imaging sensors and illumination strips are substantially stationary with respect to the oral features being imaged ~~through lens based optical imaging stabilization~~, thus allowing for improved ~~image capture~~images over wand and other non-stationary type devices.

It is a feature of the present invention that the imaging strips contemplated herein are manufactured using flexible printed circuit boards to allow the imaging strips to curve along and conform to the U-shape of a mouth. The inventor contemplates manufacturing the flexible printed circuit boards of an imaging strip to comprise a thin insulating polymer film having conductive circuit patterns affixed thereto and supplied with a thin polymer coating to protect the conductor circuits, in addition to the power source connection to the tray itself to provide energy to the sensors and lenses along the strip needed to take a digital impression.

It is a feature of the present invention to acquire digital dental impression data with high accuracy and reduced scanning time while also reducing patient discomfort. The present invention is capable of utilizing a variety of image processing techniques, is energy efficient, and exhibits a high degree of reusability, all of which can contribute to an overall reduced cost for manufacturing a physical model of the dental impression.

It is a feature of the present invention to utilize the images and digital dental impression data and transform them into a visual representation on a display and provide a sufficient set of data to provide a three-dimensional representation of the patient's upper or lower teeth as well as information about a patient's jaw.

Embodiments include one, more, or any combination of all of the features listed above. Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1A is an upper perspective view of an oral imaging system, in accordance with an exemplary embodiment of the present invention;

FIG. 1B illustrates a top view of the dental tray shown in **FIG. 1A**, in accordance with an exemplary embodiment of the present invention;

FIG. 1C illustrates a side view of the dental tray shown in **FIG. 1A**, in accordance with an exemplary embodiment of the present invention;

FIG. 2A is an upper perspective view of an alternative oral imaging system, wherein the system is in a stacked configuration and each dental tray incorporates an extraoral extension, in accordance with an exemplary embodiment of the present invention;

FIG. 2B illustrates a top view of the dental trays shown in **FIG. 2A**, in accordance with an exemplary embodiment of the present invention;

FIG. 2C illustrates a side view of the dental trays shown in **FIG. 2A**, in accordance with an exemplary embodiment of the present invention;

FIG. 2D illustrates a perspective view of an extraoral attachment, in accordance with an exemplary embodiment of the present invention;

FIG. 2E illustrates a side cross-sectional view at the first longitudinal center plane of the dental trays shown in **FIGs. 2A - 2C**, in accordance with an exemplary embodiment of the present invention;

FIG. 3A illustrates a close-up top view of a section of an imaging strip in a condensed matched configuration, in accordance with an exemplary embodiment of the present invention;

FIG. 3B illustrates a cross-sectional view of a section of the imaging strip shown in **FIG 3A**, in accordance with an exemplary embodiment of the present invention;

FIG. 4A illustrates a top view of an embodiment of an imaging strip for generating oral images using an expanded matched configuration, in accordance with an exemplary embodiment of the present invention;

FIG. 4B illustrates a top view of an embodiment of an imaging strip for generating oral images using a condensed alternating configuration, in accordance with an exemplary embodiment of the present invention;

FIG. 4C illustrates a top view of an embodiment of an imaging strip for generating oral images using an expanded alternating configuration, in accordance with an exemplary embodiment of the present invention;

FIG. 5A is an upper perspective view of an alternative oral imaging system, wherein the system is in a stacked configuration, and the lower dental tray incorporates a ramp, in accordance with an exemplary embodiment of the present invention;

FIG. 5B illustrates a bottom view of the lower dental tray of **FIG. 5A**, in accordance with an exemplary embodiment of the present invention;

~~FIG. 5C illustrates a side view of the dental trays shown in FIG. 5A, in accordance with an exemplary embodiment of the present invention;~~

FIG. 6 illustrates a flow chart of one embodiment of the oral imaging system consistent with embodiments of the present disclosure;

FIG. 7 illustrates a flow chart of one embodiment of the image acquisition method consistent with embodiments of the present disclosure; and

FIG. 8 illustrates a flow chart of one embodiment of the image processing module consistent with embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE DISCLOSED EMBODIMENT

Illustrative embodiments of the invention are described below in the accompanying Figures. The following detailed description provides detailed schematics for a thorough understanding of and an enabling description for these embodiments. One having ordinary skill in the art will understand that the invention may be practiced without certain details. In other instances, well-known structures and functions have not been shown or described in detail to avoid unnecessarily obscuring the description of the embodiments. In the description, terms such as “upper”, “lower”, “top”, “bottom”, “inner”, and “outer” should be construed to refer to orientation as then described or as shown in the drawings under discussion. The terms are for convenience of description and do not require that the system or component of the system be operated in a particular orientation.

FIG. 1A is an upper perspective view of an oral imaging system **100**, in accordance with an exemplary embodiment of the present invention. **FIG. 1B** illustrates a top view of the dental tray **10** shown in **FIG. 1A**, in accordance with an exemplary embodiment of the present invention. **FIG. 1C** illustrates a side view of the dental tray **10** shown in **FIG. 1A**, in accordance with an exemplary embodiment of the present invention. The oral imaging system **100** may comprise a dental tray **10** equipped with one or more imaging strips **20**, a handle **41** extending therefrom the dental tray **10**, and a first communication link **83** between the dental tray **10** and a computing device **80**. The dental trays **10** for the lower dental region and the upper dental region are each defined by a generally U-shaped channel formed to at least partially surround the teeth and gums of a patient, whereby the U-shaped channel may comprise an inner wall **11**

having inner internal surface **11a** and inner external surface **11b**, an outer wall **12** having outer internal surface **12a** and outer external surface **12b**, and a base **13** interconnecting the inner wall **11** and the outer wall **12** and having a base internal surface **13a** and a base external surface **13b**.

The imaging strips **20** may be adhered directly to or incorporated within any one or more of internal surfaces **11a**, **12a**, or **13a**, or outer external surface **12b**, and each imaging strip **20** is generally length-wise oriented parallel with the curvature of a corresponding internal surface **11a**, **12a**, **13a**, or **12b**. The computing device **80** may comprise a power source **81**, a computer-readable storage medium **82**, and a processor **85**, wherein the storage medium **82** may include a 12 control module **91** and an image processing module **92**. Printed circuit boards **25** housed within the imaging strips **20** or within the body of the dental tray **10** transmit or receive electrical or imaging signals between the imaging strips **20** and the computing device **80** via first communication link **83**, which may be a transmission cable or wireless transmitter and receiver. Images and other information acquired or generated by the imaging system **100** may be communicated to a visual display for viewing. The power source **81** provides power to components of the dental tray and/or the computing device **80**.

FIG. 2A is an upper perspective view of an alternative oral imaging system **100**, wherein the system **100** is in a stacked configuration and each dental tray **10** incorporates an extraoral extension **15**, in accordance with an exemplary embodiment of the present invention. **FIG. 2B** illustrates a top view of the dental trays **10** shown in **FIG. 2A**, in accordance with an exemplary embodiment of the present invention. **FIG. 2C** illustrates a side view of the dental trays **10** shown in **FIG. 2A**, in accordance with an exemplary embodiment of the present invention. **FIG. 2D** illustrates a perspective view of an extraoral attachment **15**, in accordance with an exemplary embodiment of the present invention.

FIG. 2E illustrates a side cross-sectional view at the first longitudinal center plane **1** of the dental trays **10** shown in **FIG. 2A – 2C**, in accordance with an exemplary embodiment of the present invention.

In this example embodiment, two dental trays **10** are in a stacked configuration with the base external surface **13b** of the upper dental tray **10** positioned adjacent to a base external surface **13b** of the lower dental tray **10** about a second longitudinal center plane **2**, each dental

tray **10** having an extraoral extension **15** so that both the upper, lower, internal and external sections of a mouth may be scanned and imaged simultaneously. The extraoral extensions **15** reversibly fasten to the dental trays **10** proximate to the handles **41**, if scanning of the mouth exterior is desired by the user. An extraoral extension **15** may comprise an extraoral elongation **16**, a clipping member **17**, and one or more imaging strips **20**. The clipping member **17** inserts into a receiving member positioned within the volume of each dental tray **10** proximate to the respective handle **41**. The extraoral elongation **16** has an extension internal surface **16a** and is designed to be positioned closely against the lips or the extraoral region of a user by curving towards a respective dental tray **10** with increasing distance from the first longitudinal center plane **1**. The dental tray **10** for the upper dental region may further comprise a central inner platform **14** connecting the two opposing sides of the inner wall **11**.

In this example embodiment, additional imaging strips **20** may be adhered directly to or incorporated within any one or more of surfaces **12b** or **16a**, and each imaging strip **20** is generally length-wise oriented parallel with the curvature of a corresponding surface of either **12b** or **16a** or within the palatal section of the dental tray **10**. Each type of imaging strip **20** is manufactured to substantially match the contour of a corresponding surface **11a**, **12a**, **12b**, **13a** or **16a**. An imaging strip **20** may be securely fastened to the inner internal surface **11a** for generating oral images of the inner gums and inner side of the teeth or inner oral structures. An imaging strip **20** may be securely fastened to the outer internal surface **12a** for generating oral images of the outer side of teeth and outer gums or outer oral structures. An imaging strip **20** may be securely fastened to the base internal surface **13a** for generating oral images of the teeth crowns and lower gums or lower oral structures. An imaging strip **20** may be securely fastened to the outer external surface **12b** for generating oral images of the inner side of the lips. An imaging strip **20** may be securely fastened to the extension internal surface **16a** for generating oral images of the outer side of the lips.

Furthermore, the oral imaging system **100** may further comprise a second communication link **84** between the computing device **80** and the second dental tray **10** for transmitting or receiving electrical or imaging signals between the imaging strips **20** on the second dental tray **10** and the computing device **80**.

In some embodiments, any of the dental trays **10** may further comprise an internal power source **51**, an internal memory **52**, or an internal processor **53**. It is contemplated that

internal power source **51** may include a button cell battery located on or within the handle **41** of a dental tray **10**, a rechargeable battery powered by an induction coil located on ~~the outside surface of the handle 41~~ or within the handle **41** of a dental tray **10** that may be placed into sufficient physical contact with another induction coil on a flat surface of a charging base station, a rechargeable battery that can be recharged by one or more external charging connection pins on the surface of the dental tray **10** that are placed into sufficient physical contact with charging connection pins on a charging base station wherein the dental tray may be securely stored during the charging process, or a rechargeable battery that may be connected to an external power source via a cable to recharge. A millimeter wave wireless receiver placed in the handle **41** of the dental tray **10** may be wirelessly powered via a base station broadcasting a compatible signal to send wireless power to a receiver in the handle **41**. Use of induction based wireless charging herein is contemplated because there would be a smaller area wherein moisture could accumulate within the interior portions of the tray **10**. ~~In addition to a charging station, a contemplated base station may also include a means to sterilize a dental tray 10 via one or more ultraviolet lights placed above and around the dental tray 10 or through activating a haptic chip at or near the surface of the charging station wherein cavitation and implosion is achieved via ultrasonic agitation of a fluid or solvent within a charging station.~~ Internal memory **52** may be a solid state drive or other computer-readable storage medium capable of storing information from the illumination strips **20** prior to transmitting signals to the computing device **80**. Internal processor **53** may be configured to process various forms of data between the computing device **80** and the internal memory **52**.

FIG. 3A illustrates a close-up top view of a section of an imaging strip **20** in a condensed matched configuration, in accordance with an exemplary embodiment of the present invention.

FIG. 3B illustrates a cross-sectional view of a section 4 of the imaging strip 20 shown in **FIG 3A**, in accordance with an exemplary embodiment of the present invention. Each imaging strip **20** may comprise ~~one or more~~an illumination ~~strips~~strip **21** and a plurality of imaging sensors **22** ~~along the imaging strip 20 as an array~~. The illumination strips **21** may comprise a plurality of adjacently positioned individual light sources or may be a single continuous illuminating extension. The illumination strips **21** are configured to provide illumination to the region of the mouth being imaged and are generally either light emitting diodes (LED), structured striped light, lasers, infrared sources, other coherent light sources, or combinations thereof. The imaging sensors **22** are configured to acquire images of the teeth and gum regions of the mouth

and transmit the acquired images to the computing device **80** via printed circuit boards **25** and communication links **83** and **84**. A variety of imaging sensors **22** may be used including, but not limited to, optical imaging sensors, time of flight sensors, laser sensors, blue CAM sensors, back-illuminated CMOS, three-dimensional cameras, optical coherence tomography (OCT), other various types of optical camera sensors, or combinations thereof. ~~The imaging sensors 22 may also include lens-based optical imaging stabilization for more accurate imaging via an internal floating lens element within the sensor, wherein the floating lens is electronically controlled and shifts the lens opposite to the direction a lens is moved.~~ The inventor contemplates using one or more wide-angle imaging sensors along the imaging strip in order to capture a plurality of close-up images which may then be transformed for sharpness and then consolidated into a single three-dimensional impression image via imaging software that may then be output to a display. Furthermore, it is contemplated that the imaging system **100** could be improved by including a hydrophobic coating onto the outer surface of the imaging sensors **22** for preventing fog or condensation on the surface of the sensors **22**.

The illumination strips **21** and imaging sensors **22** may be directly attached between a first cover layer **23** and a second cover layer **24**. The first cover layer **23** and second cover layer **24** protect the illumination strips **21** and imaging sensors **22** from damage caused by abrasion and bodily fluids and are manufactured from a polymer exhibiting a substantially high transparency and at least partial flexibility. The inventor contemplates using polyimide, polyester, or a similar polymer as a base material for a flexible printed circuit board **25** used for the imaging strip **20** and connecting the imaging strip **20** to a power source **51** or **81**, illumination strips **21**, imaging sensors **22**, or other electronic components. The first cover layer **23** provides a minimal imaging distance between the imaging sensors **22** and the target to be imaged and exhibits a substantially high transmissivity of light. The second cover layer **24** houses the illumination strips **21**, the imaging sensors **22**, and printed circuit boards **25**. In various embodiments, one or more of the imaging strips **20** may each comprise one or more fluid collection channels **31** extending along the back portion **35** of at least one transverse end portion **36** of the imaging strip **20** and each being designed to communicate fluid from one or more blow channels **32** to a vacuum. The fluid collection channels **31** may have either a semi-elliptical cross section or may have holes along the length of each fluid collection channel **31** and generally converge into a main fluid channel **37** located near and within the handle **41** of the dental tray **10** before terminating at a blower/vacuum line **42**, or channel, that attaches to a pressurized air supply or vacuum. The blow channels **32** generally extend adjacently along the

transverse end portions **36** and communicate fluid from the blow channel openings **33** to the fluid collection channels **31**. In various embodiments, any imaging strip **20** with blow channels **32** may further comprise a mesh **38** for filtering particles from entering the blow channels **32**, the mesh **38** generally being positioned at the blow channel openings **33**. In various embodiments, the imaging strips **20** may further comprise one or more heating elements **26** for applying heat to the air and surfaces of the blow channels **32** or to the first cover layer **23** or second cover layer **24**. The heating elements **26** are generally positioned adjacent to and along the blow channels **32**.

FIG. 4A illustrates a top view of an embodiment of an imaging strip **20** for generating oral images using an expanded matched configuration, in accordance with an exemplary embodiment of the present invention. **FIG. 4B** illustrates a top view of an embodiment of an imaging strip **20** for generating oral images using a condensed alternating configuration, in accordance with an exemplary embodiment of the present invention. **FIG. 4C** illustrates a top view of an embodiment of an imaging strip **20** for generating oral images using an expanded alternating configuration, in accordance with an exemplary embodiment of the present invention. A user may find it advantageous to use any one of the expanded matched, expanded alternating, condensed matched, or condensed alternating configurations depending on numerous factors such as, but not limiting to, mouth size or extent of thermal dissipation from the illumination strips **21**.

FIG. 5A is an upper perspective view of an alternative oral imaging system **100**, wherein the system **100** is in a stacked configuration and the lower dental tray **10** incorporates a ramp, in accordance with an exemplary embodiment of the present invention.

FIG. 5B illustrates a bottom view of the lower dental tray **10** of **FIG. 5A**, in accordance with an exemplary embodiment of the present invention. ~~FIG. 5C illustrates a side view of the dental trays 10 shown in FIG. 5 A, in accordance with an exemplary embodiment of the present invention.~~ In embodiments where two dental trays **10** are in a stacked configuration, the oral imaging system **100** may further comprise a ramp **43** for acquiring the jaw position of a user. The ramp **43** may take the form of a triangular pyramid or a right triangular pyramid and may be positioned on the base internal surface **13a** of the lower dental tray **10**.

The ramp **43** may be detachable and may be sloping or inclining toward the outer internal surface **12a** near the cross-section **1**. The ramp **43** is designed to align the mandible and maxilla of a user towards the CR position when the lower front teeth contacts and presses against the lower dental tray **10**. The three-dimensional digital scanning of the jaws and recording of this position is useful in relating and positioning of the 3D scanned models of the jaws into the correct CR position. This recorded CR position is an essential record for the proper construction of simple and complex dental prostheses and mouth rehabilitation of the patients. A clip **44** may be attached to the handles **41** of stacked dental trays **10** to firmly press the dental trays **10** together and maintain the relative positions and alignment of the dental trays **10**. Other suitable methods of maintaining the relative positions and alignment of dental trays **10** in a stacked configuration include, but are not limited to, rails and respective rail inserts positioned on the base external surface **13b** of each dental tray **10**, adhesive materials applied to the base external surface **13b** of one or more dental trays **10**, or manufacturing the dental trays **10** together as a single piece. In various embodiments, one or more dental trays **10** may further comprise one or more accelerometers **45** on one of the surfaces **11a**, **12a**, or **13a**, or directly on the imaging strip **20**, as well as on any teeth, gums, or dental structures.

FIG. 6 illustrates a flow chart of one embodiment of the oral imaging system **100** consistent with embodiments of the present disclosure. The processor **85** may be configured to perform operations, tasks or actions related to obtaining images using the imaging strips **20** on the dental tray **10** or to further process the images obtained by scanning the teeth and gum regions into digital dental impressions. The computer-readable storage medium **82** may comprise modules, software and algorithms that the processor **85** implements during the steps of the image acquisition method **200**. In the embodiments described herein, representative data may refer to tabulated data, graphical data, visual data or functional relationships.

The control module **91** may comprise a blower/vacuum control **111** for controlling and adjusting the humidity and degree of either reduced or elevated pressure in the fluid collection channels **31**, an illumination control **112** for controlling and adjusting the degree of illumination for the illumination strips **21**, a camera imaging capture control **113** for controlling and adjusting the capture timing or rate of the imaging sensors **22**, and a data transmission control **114** for controlling and adjusting the transmission of images and representative data from the dental tray(s) **10** to the computing device **80**.

The image processing module **92** may comprise instructions, tasks or executable commands related to the processing of scanned images or representative data into digital dental impressions. Images or representative data from the scanning step may be further processed using a variety of techniques which include, but are not limited to, color separation and rendering techniques, multiple 3D image capture techniques, position and relation techniques, techniques using artificial intelligence, gaussian smoothing techniques, image sharpening techniques, optical coherence tomography, light detection and ranging (LiDAR), and triangulation techniques. Furthermore, the image processing module 92 may comprise instructions, tasks or executable commands related to adjusting the relative positions and orientations of the maxilla dental tray and mandible dental tray when two dental trays 10 are used simultaneously.

The image processing module **92** may comprise a still image capture module **94**, a video capture module **95**, or a real-time imaging module **96**. The still image capture module **94** uses triangulation techniques to acquire images generally by emitting light beams that intersect to identify a particular point in 3D space. For passive triangulation techniques, Equation 1 may be used to calculate the distance (d) of a target perpendicular from the plane intersecting mediums **23** and **24** from the distance (x) between the illumination strip **21** and a respective imaging sensor **22** along the plane intersecting mediums **23** and **24**, the angle (α) between the target at distance (d) and the plane intersecting mediums **23** and **24** relative to the illumination strip **21**, and the angle (β) between the target at distance (d) and the plane intersecting mediums **23** and **24** relative to the respective imaging sensor **22**.

$$d = \frac{x}{\frac{1}{\tan(\alpha)} + \frac{1}{\tan(\beta)}}$$

(Equation 1)

Furthermore, for embodiments wherein the imaging sensors **22** are fixed focus cameras, the blur or defocus of generated images may be quantified by Equation 2, where λ is the wavelength of light coming from the illumination strips **21**, r is a measure of the aperture of the imaging sensor **22**, and zof and z`of are the in-focus and actual object distances from the imaging sensor **22**.

~~$$\psi = \frac{2\pi}{\lambda}\left(\frac{1}{z_o^f} - \frac{1}{z'^f_o}\right) r^2$$~~

$$\psi = \frac{2\pi}{\lambda}\left(\frac{1}{z_o^f} - \frac{1}{z'^f_o}\right) r^2$$ (Equation 2)

The video capture module **95** uses active wavefront sampling techniques to acquire images by emitting blue wavelength light directed at the teeth, gums or dental structures that is detected by each individual imaging sensor **22** at different angles. The captured video images may then be then assembled or stitched together into a 3D rendering using a variety of well established techniques. The real-time imaging module 96 uses ultrafast optical sectioning techniques that generate 3D images based on real-time geometric representative data.

FIG. 7 illustrates a flow chart of one embodiment of the image acquisition method **200** consistent with embodiments of the present disclosure. During use and operation of the oral imaging system **100**, steps from the image acquisition method **200** may be implemented to acquire digital dental impressions of a user's teeth and gums as well as extraoral features of the mouth and lips. The image acquisition method **200** may comprise one or more calibration steps **210**, wherein the calibration steps **210** may include the step of scanning a manufactured model of teeth and gums and adjusting parameters of the scanned image data **150** to be set substantially equal to the calibrated model. The image acquisition method **200** may comprise one or more device placement steps (Block **220**), which generally involves insertion of the embodied device into the mouth of a user. In embodiments wherein two dental trays **10** are in a stacked configuration, the image acquisition method **200** may further comprise the step of a measuring relative bite or jaw positions (Block **230**) and the envelope of motion, the former of which is generally performed by having the user bite the dental trays **10** together, the latter of which is generally performed by having the user move the bottom jaw up, down, left, right, and diagonal within the dental tray **10** relative to the initial jaw position and comparing with the initial jaw position data. The image acquisition method **200** may comprise the step of controlling the degree of suction or blow and affecting the humidity levels proximate to the illumination strips **21** and the imaging sensors **22** (Block **240**).

The image acquisition method **200** may comprise one or more steps of controlling the extent of and the timing of illumination of one or more illumination strips **21** (Block **250**). The

image acquisition method **200** may comprise one or more steps of controlling the camera imaging capture timing of imaging sensors **22** (Block **260**).

The image acquisition method **200** may comprise one or more image acquisition steps **270** for acquiring scanned image data **150** of the targeted areas of the patient's teeth and/or gums. During the image acquisition steps **270** of the embodied device **100**, the position and orientation of the oral imaging system **100** is substantially stationary with respect to the oral features being imaged at a given time.

The image acquisition method **200** may comprise one or more steps for generating digital dental impression data **160** using the scanned image data **150** and one or more of a variety of image processing techniques (Block **290**). The 3D digital impression data **160** may then be used by suitable CAD and CAM software to generate a model for the teeth and gums of a user.

FIG. 8 illustrates a flow chart of one embodiment of the image processing module **130** consistent with embodiments of the present disclosure. The capture sequence trigger **128** may initiate the image processing module **130** at the user's desire and may generate any combination of illumination and color capture data **131**, multiple 3D image capture data **132**, position and relation data **133**, triangulation data **134**, or jaw data **135**. Color separation data **136** may be generated from illumination and color capture data **131** and may be used to generate object color data **141** or color rendering reconstruction **144**; the object color data **141** or 3D geometry compensation data **150** may also be used to generate color rendering reconstruction **144**. The color rendering reconstruction **144** may be used to generate geometry compensation **145** or display rendering **147**.

Multiple 3D image capture data **132** may be used to generate a 3D processing algorithm **137**, which may be used to generate object topography **142** that, along with geometry compensation **145**, may be used to generate a 3D reconstruction **148**. Position data **138** may be generated from position and relation data **133** or triangulation data **134** and may be used to generate a triangulation of 3D data render **143**. Relation data **139** generated from triangulation data **134** or jaw data **135** may also be used to generate a triangulation of 3D data render **143**. The triangulation of 3D data render **143** may then be used to generate a maxillary and

mandibular 3D position reconstruction **146**, which may be sent to 3D object storage **152** or used in conjunction with the 3D reconstruction **148** to generate a 3D merge **149**. The 3D merge **149** may be sent to 3D object storage **152** or to a display driver **151** and eventually to a display **153**. Data in the 3D object storage **152** may be stored within a case database **154**.

While particular embodiments of the invention have been described and disclosed in the present application, it is clear that any number of permutations, modifications, or embodiments may be made without departing from the spirit and the scope of this invention. Accordingly, it is not the inventor's intention to limit this invention in this application, except as by the claims.

Particular terminology used when describing certain features or aspects of the invention should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the invention with which that terminology is associated. In general, the terms used in the claims should not be construed to limit the invention to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the invention encompasses not only the disclosed embodiments, but also all equivalent ways of practicing or implementing the invention.

The above detailed description of the embodiments of the invention is not intended to be exhaustive or to limit the invention to the precise embodiment or form disclosed herein or to the particular field of usage mentioned in this disclosure. While specific embodiments of, and examples for, the invention are described above for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. Also, the teachings of the invention provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

All of the above patents and applications and other references, including any that may be
listed in accompanying filing papers, are incorporated herein by reference. Aspects of the invention can be modified, if necessary, to employ the systems, functions, and concepts of the various references described above to provide yet further embodiments of the invention.

In general, the terms used in the claims should not be construed to limit the invention to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the invention encompasses not only the disclosed embodiments, but also all equivalent ways of practicing or implementing the invention under the claims.

In light of the above "Detailed Description," Inventor may make changes to the invention. While the detailed description outlines possible embodiments of the invention and discloses the best mode contemplated, no matter how detailed the above appears in text, the invention may be practiced in a myriad of ways. Thus, implementation details may vary considerably while still being encompassed by the spirit of the invention as disclosed by the inventor. As discussed herein, specific terminology used when describing certain features or aspects of the invention should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the invention with which that terminology is associated.

What is claimed is:

1.- An oral imaging system comprising:

_____a dental tray in a form of a U-shaped channel formed to at least partially surround teeth and gums;

_____one or more imaging strips, each said imaging strip comprising an illumination strip and a plurality of imaging sensors; and

_____a handle extending therefrom said dental tray

2.- The oral imaging system of Claim 1, whereby said form of a U-shaped channel

_____comprises:

_____an inner wall with an inner internal surface;

_____an outer wall with an outer internal surface and an outer external surface; and

_____a base with a base internal surface and a base external surface, wherein said base interconnects said inner wall and said outer wall.

3.- The oral imaging system of Claim 2, wherein at least one said imaging strips is adhered directly to or incorporated within said inner internal surface, said outer internal surface, or said base internal surface.

4.- The oral imaging system of Claim 1, further comprising a computing device, and one or more communication links between said computing device and one or more of said dental tray, wherein said communication links are configured to transmit or receive imaging signals between one or more said imaging strips and said computing device.

5.- The oral imaging system of Claim 4, wherein said computing device comprises a power source, a computer-readable storage medium, and a processor, wherein said storage medium comprises a control module and an image processing module.

6.- The oral imaging system of Claim 1, wherein one or more said illumination strips comprises a plurality of adjacently positioned individual light sources or a single continuous illuminating extension.

7.- The oral imaging system of Claim 4, wherein one or more said imaging sensors are configured to acquire images of teeth and gum regions and transmit said images to said computing device.

8.- The oral imaging system of Claim 1, wherein imaging strip further comprises a first cover layer and a second cover layer, whereby one or more illumination strips or imaging sensors are directly adhered between said first cover layer and said second cover layer.

9.- The imaging system of Claim 1, wherein at least one said imaging strips comprises:

one or more fluid collection channels extending along a back portion of at least one transverse end portion of said imaging strip;

one or more blow channels extending adjacently along said transverse end portions and designed to communicate fluid from one or more blow channel openings to said fluid collection channels, wherein each fluid collection channels are designed to communicate fluid between one or more blow channels and a vacuum or pressurized air source.

10.- The imaging system of Claim 9, wherein at least one imaging strip comprises one or more mesh positioned at one or more blow channel openings.

11.- The imaging system of Claim 1, wherein said imaging sensors are configured into a condensed matched configuration, a condensed alternating configuration, an expanded matched configuration, or an expanded alternating configuration.

12.- The oral imaging system of Claim 1, further comprising an extraoral extension, said extraoral extension comprising an extraoral elongation with an extension internal surface, whereby said extraoral elongation is designed to be positioned in close proximity to lips or an extraoral region of a user, and whereby said extraoral extension is reversibly fastenable to said handle or to said dental tray.

13.- The oral imaging system of Claim 12, further comprising one or more additional imaging strips adhered directly to or incorporated within said extension internal surface, whereby each said additional imaging strip is oriented length-wise parallel with a curvature of said extension internal surface.

14.- The oral imaging system of Claim 5, wherein said control module comprises:

_____a humidity suction and blow control for controlling the humidity and degree of either reduced or elevated pressure in one or more said fluid collection channels;

_____an illumination control for controlling a degree of illumination for said illumination strips;

_____a camera imaging capture control for controlling a capture timing of said imaging sensors; and

_____a data transmission control for controlling transmission of representative data.

15.- The oral imaging system of Claim 5, wherein said image processing module comprises:

_____a still image capture module;

_____a video capture module; or

_____a real-time imaging module.

16.- An oral imaging system comprising:

_____a first dental tray and a second dental tray, wherein each of said first dental tray and said second dental tray a form of a U-shaped channel formed to at least partially surround teeth and gums, whereby said form of a U-shaped channel comprises an inner wall with an inner internal surface and inner external surface, an outer wall with an outer internal surface and an outer external surface, and a base with a base internal surface and a base external surface, wherein said base interconnects said inner wall and said outer wall;

_____wherein said first dental tray and said second dental tray are arranged in a stacked configuration with a first base exterior wall of said first dental tray adjacently positioned with a second base exterior wall of said second dental tray; and

_____one or more imaging strips on each of said first dental tray and said second dental tray, each said imaging strip comprising an illumination strip and a plurality of imaging sensors.

17.-___The oral imaging system of Claim 16, wherein one of two said dental trays further comprises a ramp, wherein the ramp is positioned on said base internal surface of one of said first dental tray or said second dental tray.

18. The oral imaging system of Claim 16, further comprising a clip attached to said handles for maintaining relative positions or alignment of said dental trays.

19. A method for scanning images of a mouth region, said method comprising the steps of:

placing one or two dental trays into a mouth of a patient; and

acquiring scanned image data of one or more targeted areas of the mouth ~~via one or more imaging sensors positioned along one or more surfaces of the dental trays~~.

20. The method of Claim 18, further comprising the steps of:

calibrating the oral imaging system;

measuring relative jaw positions;

controlling a degree of suction or blow and affecting humidity levels proximate to one or more illumination strips or one or more imaging sensors;

controlling an extent of and timing of illumination of one or more illumination strips;

controlling a camera imaging capture timing of one or more imaging sensors; and

generating digital dental impression data using said scanned image data.