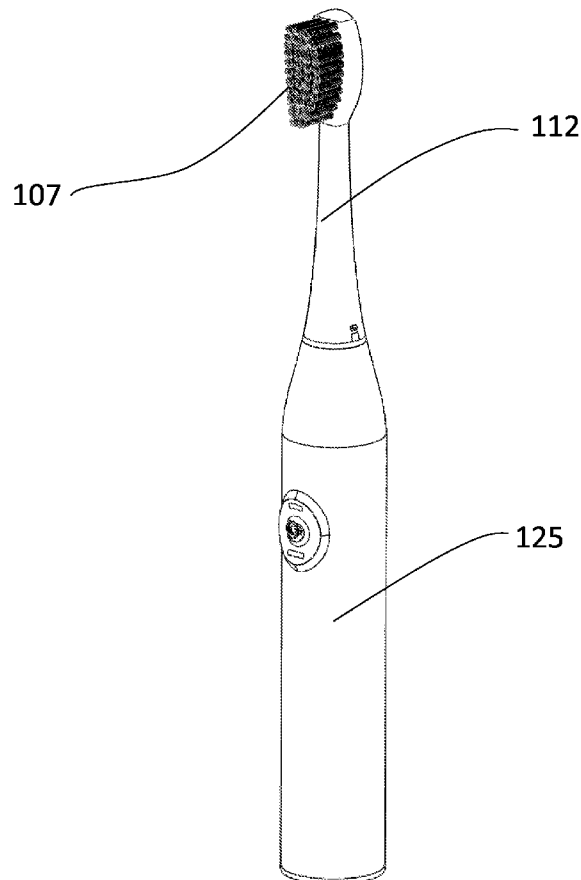




US 20140310900A1

(19) **United States**(12) **Patent Application Publication**
Curry et al.(10) **Pub. No.: US 2014/0310900 A1**(43) **Pub. Date: Oct. 23, 2014**(54) **TOOTHBRUSH AND SYSTEM WITH
SENSORS AND USER IDENTIFICATION**(71) Applicant: **Beam Technologies, LLC**, Louisville,
KY (US)(72) Inventors: **Alexander D. Curry**, Louisville, KY
(US); **Alex X. Frommeyer**, Louisville,
KY (US); **Daniel E. Dykes**, Louisville,
KY (US)(73) Assignee: **Beam Technologies, LLC**, Louisville,
KY (US)(21) Appl. No.: **14/198,071**(22) Filed: **Mar. 5, 2014****Related U.S. Application Data**(60) Provisional application No. 61/772,576, filed on Mar.
5, 2013, provisional application No. 61/781,400, filed
on Mar. 14, 2013.**Publication Classification**(51) **Int. Cl.**
A46B 9/04 (2006.01)
A46B 15/00 (2006.01)(52) **U.S. Cl.**CPC **A46B 9/04** (2013.01); **A46B 15/0038**
(2013.01); **A46B 15/0004** (2013.01); **A46B**
15/0016 (2013.01)
USPC **15/167.1**(57) **ABSTRACT**

A toothbrush provides a unique opportunity to integrate health monitoring sensors into an object widely used by the mass population daily. A toothbrush is provided with various health monitoring sensors including an orientation sensor, oximetry sensor, capacitive sensor, pressure sensor, and temperature sensor. Further, the toothbrush is comprised in a system including a data transfer medium (i.e. "smartphone") and the Cloud, which allows for data transfer between multiple platforms from the toothbrush. The system further allows for passive participation in social games with awards and incentives. The system and toothbrush further provide for active participation in brushing games to encourage proper brushing techniques. Further, the toothbrush also provides a user identification system utilizing capacitive coupling of the human body and a mobile unit that is optionally a "smartphone." The mobile unit of the user identification system may also be used for user identification by other devices that require the user to touch them for proper use.



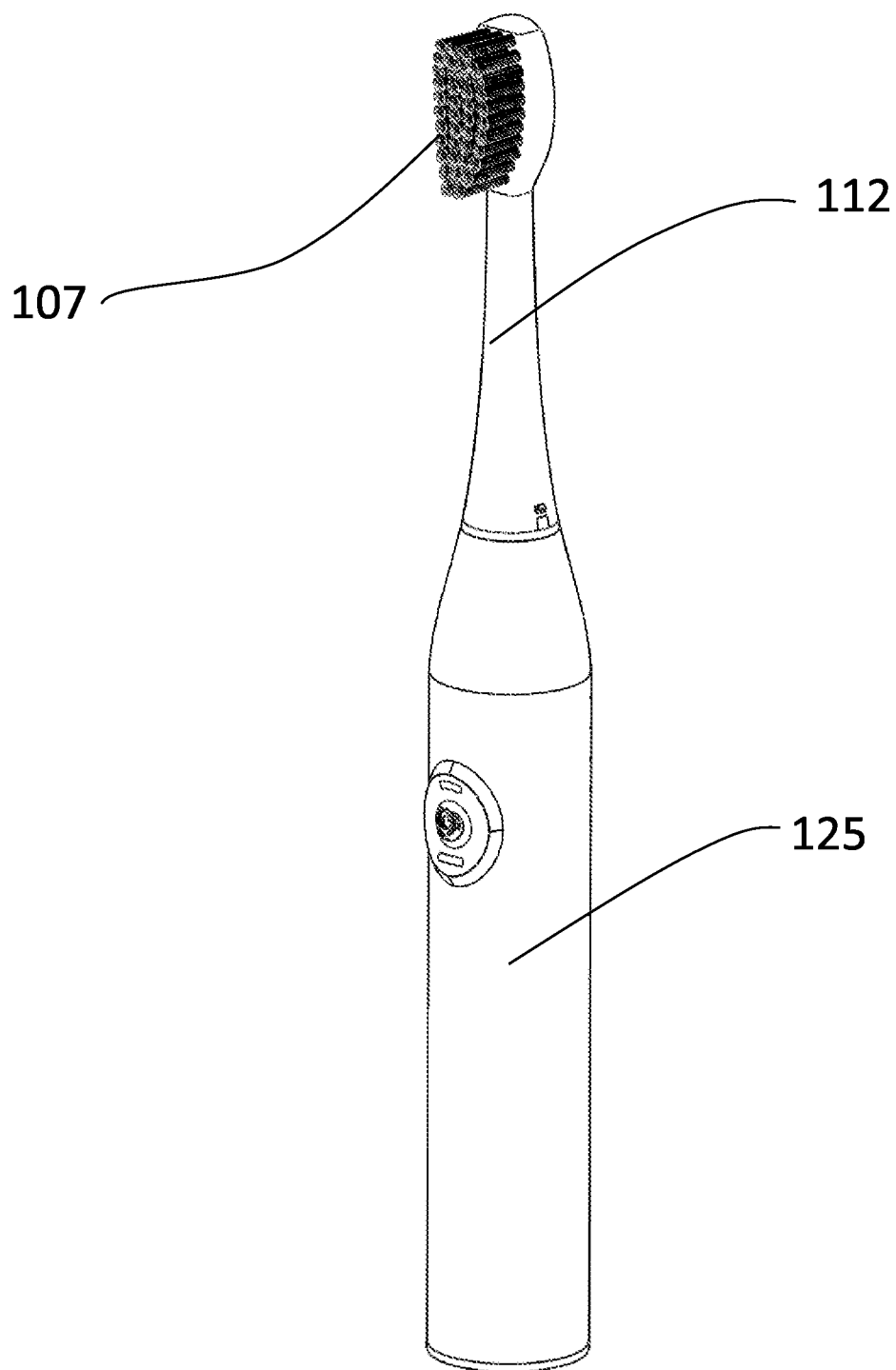


Fig. 1

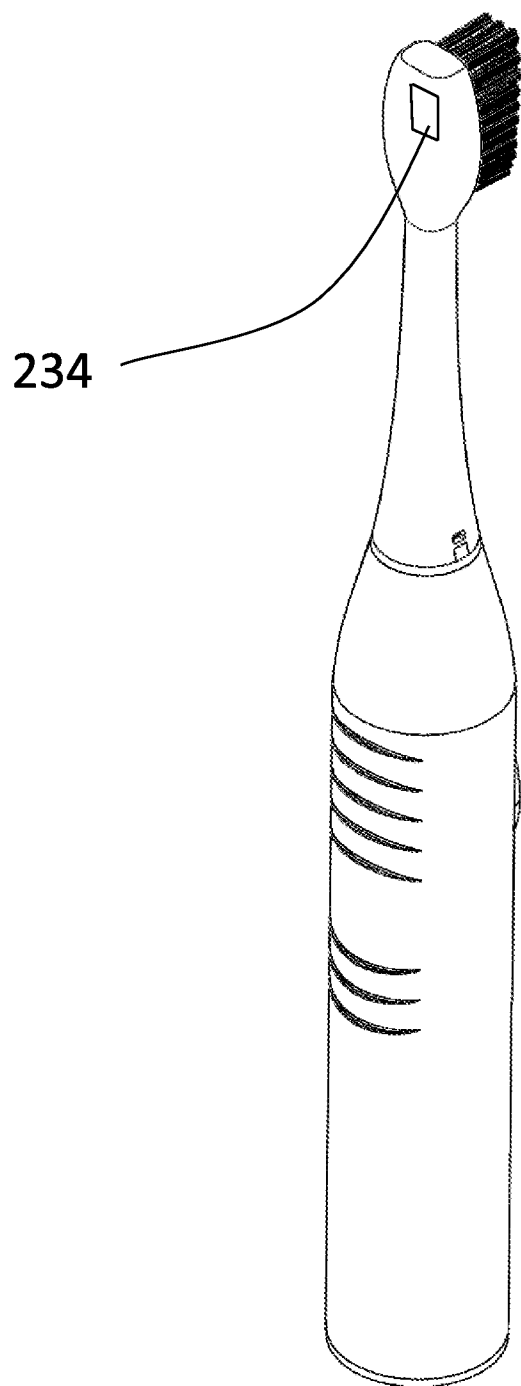


Fig. 2

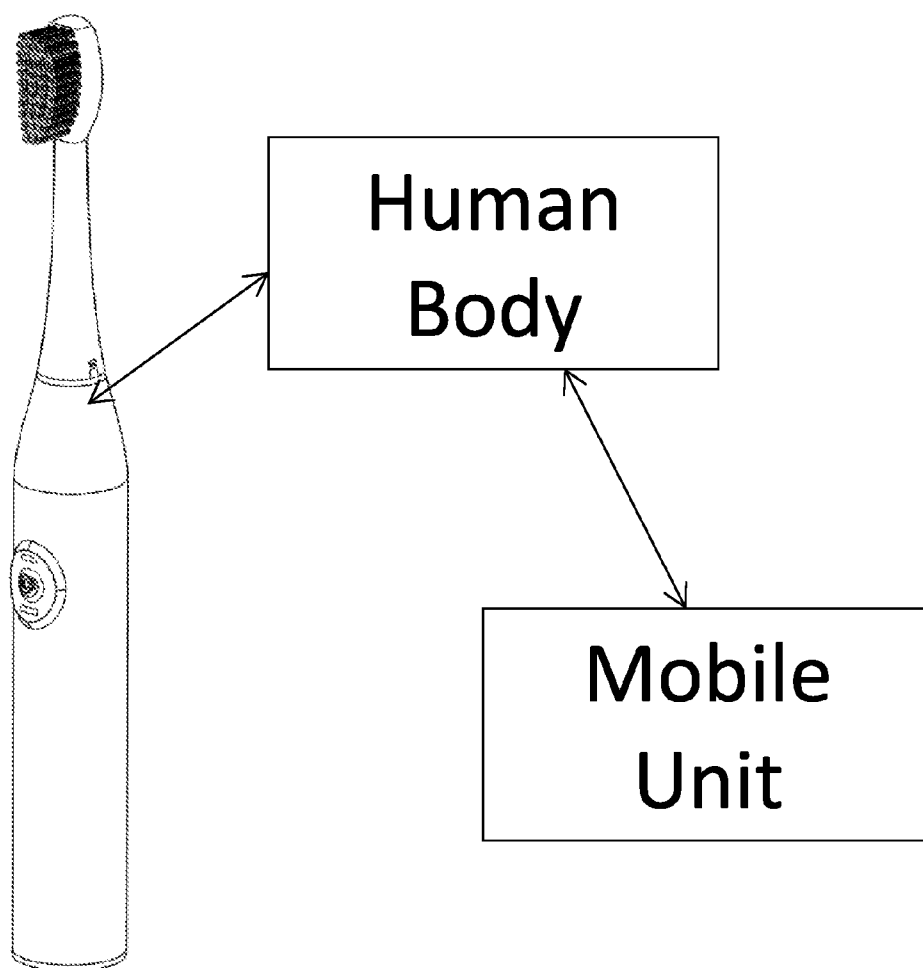


Fig. 3

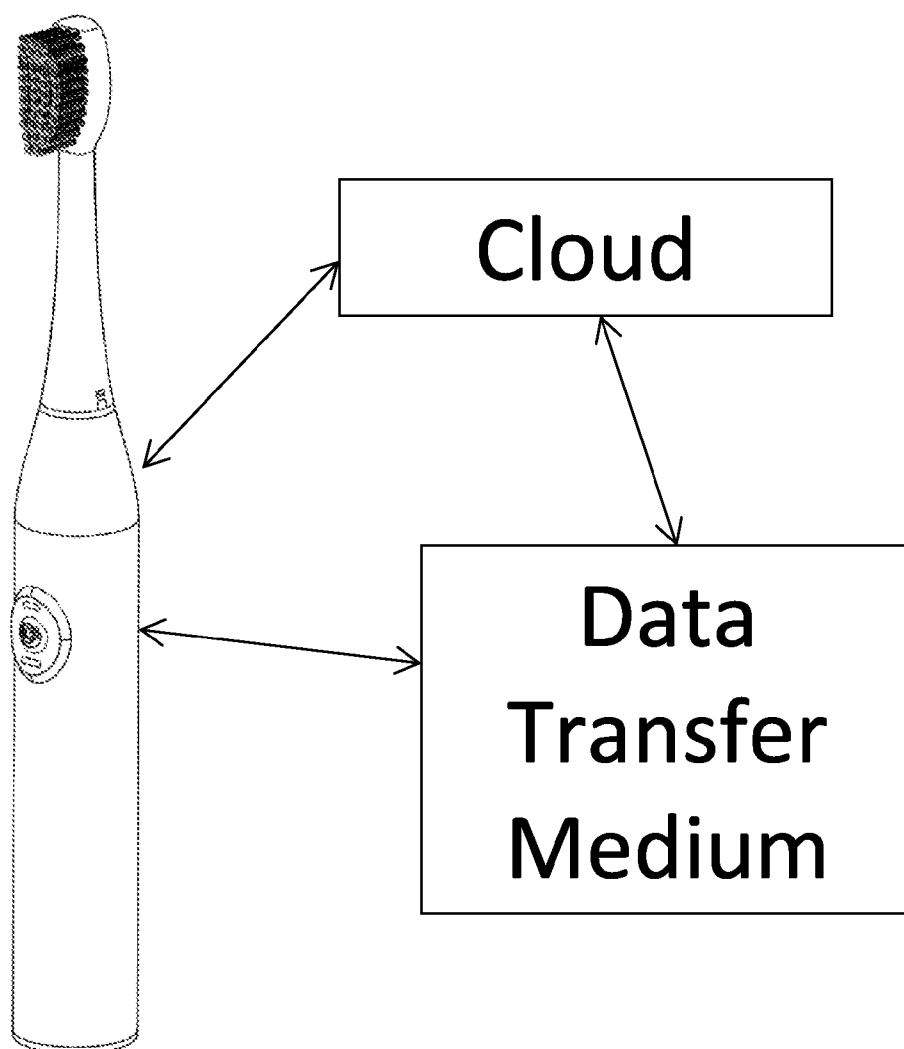


Fig. 4

TOOTHBRUSH AND SYSTEM WITH SENSORS AND USER IDENTIFICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 61/772,576 filed on Mar. 5, 2013, and U.S. Provisional Application No. 61/781,400 filed on Mar. 14, 2013.

BACKGROUND OF THE INVENTION

[0002] This invention relates to oral health care implements and systems, particularly relating to improved toothbrushes utilizing new technologies for the dental field. In particular, the invention relates to the toothbrushes with sensors and user identification capabilities.

[0003] Dental plaque is a biofilm that forms naturally on teeth between brushing and dental visits. Dental plaque can be a precursor to more severe oral health problems including: dental caries, tooth decay, gingivitis, and chronic periodontitis. The occurrence of dental caries is one of the largest health epidemics in the world and is the most common chronic childhood disease in the United States. Likewise, gingivitis and dental calculus are two of the most common systemic diseases of the body. It is desirable to more effectively remove dental plaque early stage as a preventive measure against more serious disease states. The most common preventive measure implemented to control the formation of dental plaque is the toothbrush.

[0004] Further still, clinical dental visits with dental practitioners are a method of prevention and detection of dental plaque. Regular dental visits are recommended to occur every six months. Regular toothbrush replacement is recommended to occur every three months according to dental practitioners. The lack of adherence to these recommendations and lack of brushing compliance is often a contributing factor to the development of dental plaque and its associated complications. Regular replacement of toothbrushes is often disregarded by users and cause issues as bristles become deformed and are no longer providing the proper cleaning.

[0005] Additionally, the introduction of data logging in toothbrushes presents unique challenges to the existing toothbrush market. It is common for more expensive powered toothbrush bases to be used by multiple users that interchange heads depending on the user. This provides the challenge of identifying the user that is currently using the toothbrush base and logging data.

[0006] Consequently, consumers and medical professionals are in need of a toothbrush with sensors to monitor various health statistics through course of a normal daily activity. Moreover, consumers and medical professionals are in need daily monitoring to facilitate predicative health models. Further, consumers are in need of incentives for completing daily routines to encourage proper preventative health. Consequently, a method for identifying multiple users of the same toothbrush handle is desirable for consumers.

BRIEF SUMMARY OF THE INVENTION

[0007] The invention aims to provide an improved toothbrush and system with various sensors for the detection of various health statistics and conditions. The toothbrush has bristles for cleaning and is often provided in a system further

comprising a data transfer medium and the Cloud, which allows for data transfer between multiple platforms from the toothbrush.

[0008] The health monitoring sensors include an orientation sensor that measures the orientation of the toothbrush. Further, the health monitoring sensors include an oximetry sensor that measures heart rate and blood oxygenation. Other health monitoring sensors include a capacitive sensor for measuring proximity, a pressure sensor for measuring brushing pressure, and a temperature sensor for measuring body temperature.

[0009] Additionally, the toothbrush is part of a user identification system that utilizes capacitive coupling of the human body and a mobile unit, wherein the mobile unit identifies the user to the toothbrush. In some instances, the mobile unit is a "smartphone" (i.e. data transfer medium) that is carried by the user.

[0010] Accordingly, several advantages are to provide a toothbrush, to provide various health monitoring sensors for monitoring different health statistics, to provide transmission of data from the toothbrush to either a data transfer medium or the Cloud, and to provide user identification to the toothbrush. Still further advantages will become apparent from a study of the following descriptions and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a perspective view of a toothbrush with bristles according to multiple embodiments and alternatives.

[0012] FIG. 2 is a rear perspective view of a toothbrush with bristles and a temperature sensor according to multiple embodiments and alternatives.

[0013] FIG. 3 is a flow diagram of a toothbrush system with user identification according to multiple embodiments and alternatives.

[0014] FIG. 4 is a flow diagram of a connected toothbrush system according to multiple embodiments and alternatives.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The toothbrush and system with sensors and user identification is encompassed in a plurality of embodiments that shall be discussed in the present section.

[0016] A plurality of embodiments comprise a toothbrush. A toothbrush is an oral health care implement used for the cleaning of teeth and gingiva, more commonly referred to as gums. The toothbrush is operated in the oral cavity of a human being characterized as the first portion of the alimentary canal that receives food and saliva, and containing a mucous membrane epithelium lining referred to as the oral mucosa. The oral cavity is further characterized as having alveolar arches typically containing teeth, which are either natural, synthetic, or a combination thereof, and used primarily for the preparatory chewing of food for digestion.

[0017] A toothbrush comprises a brush head 112 consisting of a plurality of bristles 107 arranged into compact clusters, often referred to as tufts, mounted onto the brush head. Accordingly, the tufts are often mounted in an intentional pattern to facilitate cleaning of teeth and gums. A toothbrush further comprises a handle 125 that extends proximally from the brush head and is used for grasping and movement of the toothbrush. The bristles 107 of the toothbrush are commonly manufactured from either a natural material, synthetic material, or a combination thereof. One example of a natural

bristle material is animal hair. An example of a typical synthetic bristle material is Nylon.

[0018] In some further embodiments, the toothbrush comprises a flosser. A flosser is an oral health care implement used for the removal of good and dental plaque from teeth, especially between teeth and other places a toothbrush cannot effectively clean. A flosser comprises a flosser head having two parallel protrusions with space between them such that a length of dental floss can be placed between the two protrusions. The dental floss is, most often, held taut by the two protrusions to facilitate proper cleaning. Two common orientations exist for the protrusions in relation to the major axis of a handle including F-shaped wherein the protrusions are generally perpendicular to the major axis of the handle; and the Y-shaped wherein the protrusions are generally parallel to the major axis of the handle.

[0019] Inherently, a toothbrush has an associated motion when in use, which is characterized as either manually driven (i.e. manual toothbrush) or electromechanically driven (i.e. powered toothbrush). A manually driven motion is regarded as a motion generated by the user by his/her own power. Conversely, an electromechanically driven motion is characterized as a motion generated by electrical power which is converted to mechanical power used to create the specified electromechanically driven motion. In some embodiments, the electromechanically driven motion is a side-to-side oscillating motion also referred to as vibratory motion. Often, the vibratory motion is generated by an electric motor with an eccentric weight on the drive shaft of the electric motor. In other instances, the vibratory motion is generated by an electrically conductive coil around the outside of a magnetic mass, such that when an alternating current is applied to the coil, the magnetic mass oscillates causing vibration of the toothbrush. In other embodiments, the electromechanically driven motion is a rotation-oscillation motion wherein the head rotates either clockwise or counter-clockwise and then rotates in the opposite direction of the first rotation. Additionally, a portion of the brush head may move in a translational motion to provide additional cleaning.

[0020] In the case of a powered toothbrush, the user is required turn "on" the electromechanically driven motion via a user input. Optionally, the user input may be the actuation of a button or switch. Additionally, the user input may be the activation of a capacitive sensor recognizing that the user has touched a specified region of the toothbrush. Conversely, the powered toothbrush often requires the user to "off" the electromechanically driven motion. This is often achieved via the same user input that is used to turn "on" the electromechanically driven motion. Inherently, at least one period of time lapses between the electromechanically driven motion being turned "on" and turned "off." This period of time can be recognized as the toothbrush usage time. Thus, the user can monitor his/her toothbrush usage time based on the turning "on" and "off" of the electromechanically driven motion.

[0021] The toothbrush further comprises a data processing unit having at least one collector, a storage medium, and at least one processor, wherein the collector, storage medium, and processor, respectively, collect, store, and process data. Accordingly, the data processing unit is chosen from the group microprocessor, microcontroller, field programmable gate array (FPGA), digital signal processing unit (DSP), application specific integrated circuit (ASIC), programmable logic, and combinations thereof.

[0022] Additionally, in some embodiments, the collector of the data processing unit is an electrically conductive wire, wherein the electrically conductive wire receives the electrical output of various sensors.

[0023] Moreover, the storage medium of the data processing unit is comprised of volatile memory and non-volatile memory, wherein volatile memory is used for short-term storage and processing, and non-volatile memory is used for long-term storage. Accordingly, volatile memory is chosen from the group random-access memory (RAM), dynamic random-access memory (DRAM), double data rate synchronous dynamic random-access memory (DDR SDRAM), static random-access memory (SRAM), thyristor random-access memory (T-RAM), zero-capacitor random-access memory (Z-RAM), and twin transistor random-access memory (TTRAM). Non-volatile memory is chosen from the group read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), flash memory, ferroelectric random-access memory (FeRAM), magnetoresistive random-access memory (MRAM), phase-change memory (PRAM), conductive-bridging random-access memory (CBRAM), silicon-oxide-nitride-oxide-silicon memory (SONOS), resistive random-access memory (RRAM), race-track memory, nano-random-access memory (NRAM), and Millipede memory.

[0024] The processor of the data processing unit is chosen from the group microprocessor and micro controller.

[0025] Optionally, the toothbrush further comprises at least one data extractor, such that the data can be extracted to be used by another medium. The data is packaged as at least one signal and transmitted to another medium. The data extractor is chosen from the group universal serial bus (USB), serial port, wired Ethernet port, radio frequency, microwave communication, infrared short-range communication, near field communication, Wi-Fi, and Bluetooth®.

[0026] In some embodiments, the toothbrush further comprises an orientation sensor. Optionally, the orientation sensor is at least one accelerometer, wherein the orientation sensor measures the acceleration of the inertial reference frame relative to itself. The inertial reference frame is defined as the reference frame where an object is in free-fall (i.e. not resisting gravity). Additionally, in some embodiments, the accelerometer is a microelectromechanical system (MEMS) comprised of a cantilever beam with a proof mass where damping results from a residual gas sealed inside the accelerometer. Piezoelectric material is often used to convert the mechanical motion into an electrical signal.

[0027] Optionally, the orientation sensor is at least one gyroscope, wherein the orientation sensor measures orientation based on the principle of conservation of angular momentum. Alternatively, the orientation sensor measures orientation based on the physical principle that a vibrating object tends to continue vibrating in the same plane as its support rotates, otherwise known as a vibrating structure gyroscope. In further options, the gyroscope is a microelectromechanical system. Accordingly, the microelectromechanical system that is a vibrating structure gyroscope utilizes a mechanism chosen from the group piezoelectric gyroscope, which uses a piezoelectric material to induce vibration; wine glass resonator, which uses a hemisphere that is driven to resonance; tuning fork gyroscope, which uses two test masses that are driven to resonance; vibrating wheel

gyroscope, which uses a wheel that is driven a fraction of a full turn about its axis; and any combination thereof.

[0028] Optionally, the orientation sensor is at least one accelerometer and at least one gyroscope, wherein the accelerometer and the gyroscope operate in conjunction to produce measurement of the full six degrees of freedom. The full six degrees of freedom are characterized as forward/backward, up/down, left/right, pitch, yaw, and roll.

[0029] Accordingly, in some embodiments, the data processing unit and the orientation sensor, both of the toothbrush, operate in conjunction to provide means for determining position of the brush head within the oral cavity. The orientation sensor detects the orientation of the toothbrush and transmits a signal to the data processing unit. The collector of the data processing unit receives the signal, and the storage medium stores the signal in the form of data. The processor of the data processing unit operates in conjunction with the storage medium to compare the stored orientation data to previously stored orientation data that correlates to certain positions within the oral cavity. Optionally, the previously stored orientation data that correlates to certain positions within the oral cavity is collected by placing the brush head of the toothbrush at various predetermined positions within the oral cavity, wherein the orientation sensor output is stored at each predetermined position, thus creating correlation data for comparison. Additionally, the toothbrush position data can be correlated to time data provided by RTCC based on motor actuation or capacitive touch sensor data to provide the user with brushing time measurements segmented by different positions within the oral cavity.

[0030] In some embodiments, the toothbrush further comprises an oximetry sensor. Optionally, the oximetry sensor is a transmissive pulse oximeter or a reflective pulse oximeter, wherein both types of oximetry sensors detect blood oxygen saturation and/or heart rate.

[0031] The transmissive pulse oximeter comprises two distinct sides that are parallel with a space separating the two sides creating a measuring site such that a portion of the human body may be inserted between the two sides. The portion of the human body most often inserted in the measuring site is chosen from the group index finger, middle finger, ring finger, pinky finger, thumb, toe, ear lobe, and nose. Two light-emitting diodes (LED) are at least partially contained on the first parallel side creating an emitter. In some embodiments, the two LEDs produce beams of light at different frequencies, which include the range of about 600-750 nanometers (nm) and the range of about 850-1000 nm such that the frequencies produce red and infrared light, respectively. Additionally, the second parallel side comprises a photo detector positioned to be opposite of the emitter such that the photo detector receives the emitted light that passes through the measuring site. The photo detector determines the amount of red and infrared light received, thus determining the amount of red and infrared light absorbed. Accordingly, the amounts of red and infrared light are transmitted to the data processing unit of the toothbrush.

[0032] Optionally, the data processing unit of the toothbrush calculates the ratio of red light to infrared light after the emitted light passes through the measuring site and is received by the photo detector. The calculated ratio is compared to a data bank that relates the calculated ratio to blood oxygen saturation values. The heart rate is further determined by the amount of light absorption of the volume of arterial blood. As the heart pumps blood, the volume of arterial blood

increases thus creating a pulsatile change in light absorption. The heart rate is determined by the frequency of pulsatile changes representing heart beats.

[0033] Optionally, the reflective pulse oximeter comprises one distinct side, referred to as the contact surface, that comprises both the light emitter and the photo detector such that the emitted light travels into the measuring site and is reflected back to the photo detector. The reflective pulse oximeter allows the user to contact only one surface on the implement. Accordingly, the reflective pulse oximeter may be contacted by the user during the normal operation of the toothbrush.

[0034] Accordingly, the reflective pulse oximeter transmits the amounts of red and infrared light received by the photo detector via the transmitter to the data processing unit. Similarly, the ratio of red light to infrared light is calculated and compared to a data bank to correlate the ratio to a blood oxygen saturation value. Additionally, the heart rate of the user is determined in the same manner as described for the transmissive pulse oximeter.

[0035] In some embodiments, at least a portion of the oximetry sensor is located on the handle such that the user contacts the oximetry sensor during normal operation of the implement. In some embodiments of the transmissive pulse oximeter, the first and second parallel sides are located on the exterior of the handle such that a user may contact the transmissive pulse oximeter when the toothbrush is fully assembled. In some embodiments, the two parallel sides are parallel to the exterior surface of the handle. Optionally, the two parallel sides are perpendicular to the exterior surface of the handle.

[0036] In some embodiments of the reflective pulse oximeter, the contact surface is positioned to be flush with the portions of the handle surrounding the reflective pulse oximeter such that the handle and the reflective pulse oximeter are comprised in a smooth surface. Optionally, the contact surface is positioned to be raised above the portions of the handle surrounding the reflective pulse oximeter such that the reflective pulse oximeter is noticeably distinct from the portions of the handle surrounding it. Optionally still, the contact surface is positioned to be flush with the portions of the handle surrounding the reflective pulse oximeter, and at least a portion of the handle not directly surrounding the reflective pulse oximeter is raised such that the reflective pulse oximeter is located in at least a partial depression indicating where the user shall place his/her thumb for contact with the contact surface.

[0037] In some embodiments, the oximetry sensor may be a plurality of transmissive pulse oximeters. In some embodiments, the oximetry sensor may be a plurality of reflective pulse oximeters. Also, in some embodiments, the oximetry sensor may be a combination of at least one transmissive pulse oximeter and at least one reflective pulse oximeter.

[0038] In some cases of a powered toothbrush comprising an oximetry sensor, heart rate data collected by the oximetry sensor is used to control the frequency of the motor's actuations. Examples include controlling the frequency of side-to-side vibrations exerted by an electric motor with an eccentric weight by pulsating the motor proportionally to heart rate data. Accordingly, the frequency control may be performed in real-time such that brushing motion and intensity correspond to the user's heart rate. This method of controlling a motor provides the user with an active monitor of when the oximetry sensor is collecting data. Therefore, if the oximetry sensor is

collecting data from the user using the powered toothbrush, then the user is notified by the pulsations of the motor in sync with the user's heart rate. Accordingly, the oximetry sensor collects heart rate data and transmits said data to the data processing unit of the toothbrush, wherein the data processing unit then controls the motor using the input heart rate data from the oximetry sensor.

[0039] In some cases of a powered toothbrush comprising a sensor, the powered toothbrush is turned "on" by the sensor recognizing the user is holding the device. Optionally, the powered toothbrush is turned "on" when the oximetry sensor detects a heart rate from the user. Further, the powered toothbrush is turned "off" when the oximetry sensor no longer detects a heart rate from the user. This allows the user to turn the powered toothbrush "on" and "off" by activating the oximetry sensor with his/her heart rate. In this case, the powered toothbrush is only "on" when the user has his/her hand properly placed on the oximetry sensor, thus requiring the user to collect valid and usable oximetry data while performing the daily task of brushing his/her teeth.

[0040] Optionally, the powered toothbrush is turned "on" after the oximetry sensor completes a measurement from the user for a specified amount of time. Accordingly, the user is required to provide a valid oximetry measurement before the powered toothbrush is turned "on." This method incentivizes the user to collect oximetry data prior to performing the daily task of brushing his/her teeth. Thus, oximetry measurements are taken on a consistent basis by the user in tandem with brushing his/her teeth and providing an overall better data set that may provide trends from oximetry data. Further, this method of turning "on" the powered toothbrush may be utilized for various sensors such that the user is collecting data on a consistent basis for various sensors and providing overall better data sets for said sensors.

[0041] In some embodiments, the toothbrush further comprises at least one capacitive sensor. One type of capacitive sensor is a capacitive sensor that works with a frequency change, alternatively referred to as a frequency change capacitive sensor. Optionally, another type of capacitive sensor is a capacitive sensor that works with a capacitive voltage divider, alternatively referred to as a voltage divider capacitive sensor. Both types of capacitive sensors detect the added capacitance of the human body.

[0042] The frequency change capacitive sensor comprises a sensor surface, a resistor-capacitor (RC) circuit, and an RC oscillator, wherein the capacitance of the human body introduced by the sensor surface is a parallel capacitance in the RC circuit such that, when the capacitance of the human body is present, the overall capacitance of the RC circuit is altered. The RC oscillator operates at a set frequency controlled by the capacitance of the RC circuit. The sensor surface comes into proximity of the human body, and, consequently, the capacitance of the human body is introduced to the RC circuit by a connection between the sensor surface and the RC circuit such that the capacitance of the human body is a parallel capacitance to the RC circuit. The change in overall capacitance of the RC circuit changes the frequency of the RC oscillator, thus, indicating the human body is in proximity to the sensor surface.

[0043] In some embodiments, the frequency of the RC oscillator is compared to a reference value to determine if a change in frequency occurs; therefore, the presence of the human body is detected. Accordingly, three alternatives are presented for performing the comparison between the refer-

ence value and the frequency of the RC oscillator. One alternative is to define the reference value as a frequency equivalent to the operating frequency of the RC oscillator when the human body is not in proximity to the sensor surface. In this instance, the reference value and the frequency of the RC oscillator are both input into a frequency comparator, wherein the frequency comparator evaluates if the values are similar; and thus, indicating one way or the other.

[0044] Optionally, the second alternative for comparison of the reference value and the frequency of the RC oscillator comprises a frequency-to-voltage converter, a DC voltage reference value, and a comparator, wherein the frequency of the RC oscillator is input to the frequency-to-voltage converter and a voltage corresponding to the frequency is output. The comparator compares the output voltage of the frequency-to-voltage converter to the DC voltage reference value. The DC voltage reference value is equivalent to the output voltage of the frequency-to-voltage converter when the human body is not in proximity to the sensor surface. Accordingly, the comparator outputs a signal consistent with whether the DC voltage reference value is similar to the output of the frequency-to-voltage converter.

[0045] Optionally, the third alternative for comparison of the reference value and the frequency of the RC oscillator is to directly measure the frequency of the signal by counting the number of rising or falling edges in a defined time period utilizing a device similar to a microcontroller. In this manner, a baseline operating frequency may be established, and any deviation in frequency beyond a defined threshold will indicate the human body is in proximity to the sensor surface.

[0046] The voltage divider capacitive sensor comprises a sensor surface, which provides an analog input; a reference voltage; an analog-to-digital converter (A/D); and an A/D capacitor. The A/D is internally driven to the reference voltage such that the A/D capacitor is fully charged, and the analog input of the sensor surface is internally grounded such that the sensor surface is fully discharged. Next, the analog input of the sensor surface is internally disconnected from the ground and is internally connected to the A/D such that the A/D capacitor will discharge at least a portion of its charge to the sensor surface in order to equal the voltages of the sensor surface and the A/D capacitor. If the human body is in proximity to the sensor surface, the sensor will appear to have a larger capacitance. Said larger capacitance results in a many time smaller steady-state voltage between the A/D capacitor and the sensor as compared to the condition when the sensor is in its normal, low capacitance state. The A/D may measure the analog input and compare it to a threshold to determine if the sensor surface is in proximity to the human body. The voltage provided to the A/D will decrease in a manner indicative of the human body's proximity to the sensor surface. In some embodiments, the decrease in a manner indicative of the human body's proximity to the sensor surface is significant.

[0047] Optionally, the reference voltage, the A/D, and the A/D capacitor are comprised in a microcontroller such that circuit comprises a sensor surface with an analog input connected to the microcontroller. The A/D of the microcontroller converts the voltage provided to the A/D from an analog signal to a digital signal. The microcontroller determines whether the sensor surface is in proximity to the human body based on the digital signal.

[0048] In some embodiments, the sensor surface is a conductive material and covered with an insulator material.

Optionally, the insulator material covering the sensor surface is the same material as the outer surfaces of the toothbrush.

[0049] An issue resides with the presence of water similarly producing a capacitance that may affect the sensor surface. A desirable advancement of the present invention is to negate the issue of water unwantedly providing a capacitance indicative of the human body's proximity to the sensor surface. Consequently, the negation of water is provided by an effective thickness of insulator material separating the water from the sensor surface. The insulator material allows detection of the sensor surface in proximity to the human body but does not allow detection of the sensor surface in proximity to water.

[0050] In some embodiments, the oximetry sensor operates in conjunction with at least one capacitive sensor to improve the quality of oximetry data, namely blood oxygen saturation and heart rate. In an embodiment utilizing a reflective pulse oximeter, a network of capacitive sensors is placed around the outer bounds of the readable area of the oximetry sensor. Most often in the case of a thumb or digit being used for oximetry data, the capacitive sensor detects the presence of said body part as it approaches or passes the threshold of the outer bounds of the readable area. Thus, the capacitive sensor essentially indicates when said body part is no longer in position to obtain an accurate reading of oximetry data. Consequently, the oximetry data can be filtered to determine its accuracy based on the position of the measured body part as it coincides with the capacitive data at any given time. Alternatively, the capacitive data can be used to determine the measured body part is present on the oximetry sensor in a measurable capacity, and the capacitive data can control the activity of the oximetry sensor, such as the "on" and "off" states. Thus, the oximetry sensor shall be "on" when the body part is positioned for measurement and "off" when it is not.

[0051] In some embodiments, the toothbrush further comprises at least one pressure sensor to determine if the pressure exerted on the implement is excessive in relation to its intended use. Optionally, the pressure sensor may be constructed from two parallel conductive plates separated by an insulator such that, in the active portion of the sensor, the insulator allows for an air gap between the parallel plates, referred to as a parallel plate capacitive sensor. For example, the insulator comprises a hole that allows for an air gap between the parallel plates. Forces acting perpendicular to the plane of the parallel plates in the active region deform one conductor or both conductors. Accordingly, the parallel plates move closer together due to deformation, thus, increasing the capacitance of the sensor. Additionally, the bristles comprised in the brush head are operatively attached to at least one of the parallel plates, wherein applied pressure may be detected by the force exerted by the bristles on the brush head.

[0052] Optionally, the pressure sensor may be at least one strain gage mounted on a section of the load bearing portion of the toothbrush, such as the neck of the toothbrush. Excessive pressure exerted by brushing the user's teeth causes deflection in the neck of the toothbrush, which creates a strain. Consequently, the deflection in the neck of the toothbrush causes a strain in the strain gage, which results in a measurable variation of a certain electrical property in the strain gage, such as electrical impedance. Further still, additional strain gages may be used to determine the force exerted by brushing in more than one direction providing the user with a more enhanced overview the source of excess pressure while brushing.

[0053] Alternatively, in cases where the toothbrush exhibits an electromechanically driven motion, the pressure sensor may be based on variations in electrical properties of the electric motor, especially in instances when the shaft of said motor is coupled in some way to the brush head of the toothbrush. The threshold for excessive pressure while brushing has an associated current draw exhibited by the electric motor, such that added force on the shaft of the motor requires more current draw to maintain the motor's capacity. Consequently, the current draw of the electric motor may be monitored to determine when excessive pressure is applied to the brush head during brushing. Further, when the threshold for excessive pressure is reached, the motor can respond in a fashion as to alert the user that excessive pressure is being used while brushing.

[0054] In some embodiments, the toothbrush further comprises at least one temperature sensor **234**. The temperature sensor **234** is chosen from the group thermocouple, thermistor, resistance temperature detector (RTD), infrared temperature sensor, thermopile, thermostat, and silicon bandgap temperature sensor.

[0055] In some embodiments, the temperature sensor is at least one thermocouple, wherein the thermocouple comprises two different conductors, typically metal alloys, that produce a voltage proportional to a temperature difference between either end of the pair of conductors. Optionally, the temperature sensor is at least one thermistor, wherein the thermistor is a resistor that has a certain resistance, which varies significantly with temperature. Thermistors are generally comprised of a ceramic or polymer material.

[0056] Optionally, the temperature sensor is at least one resistance temperature detector (RTD), wherein the RTD exploits a predictable change in electrical resistance that is dependent upon a change in temperature. Often, the material of the RTD is platinum. Alternatively, the temperature sensor is at least one infrared temperature sensor, wherein the temperature of an object is determined by a portion of thermal radiation referred to as blackbody radiation emitted by the object, such that knowing the infrared energy emitted and the object's emissivity allows for the determination of the object's temperature.

[0057] Optionally, the temperature sensor is at least one thermopile, wherein the thermopile converts thermal energy into electrical energy and is comprised of one or more thermocouples connected in series or parallel. Optionally, the temperature sensor is at least one thermostat, wherein the thermostat comprises two different metals that are bonded together to form a bi-metallic strip, such that the difference in linear expansion rates causes a mechanical bending movement when heat is applied. In some embodiments, the temperature sensor is at least one silicon bandgap temperature sensor, wherein the forward voltage of a silicon diode is dependent on temperature, and the temperature is determined by comparing bandgap voltages at two different currents.

[0058] Consequently, the temperature sensor and the data processing unit, both of the toothbrush, operate in conjunction to provide data indicative of user core body temperature, wherein the user core body temperature is a user's operating temperature, which can be indicative of problems experienced by the user.

[0059] In some embodiments, the toothbrush is comprised as the base unit in a user identification system that further comprises a mobile unit and the human body. The data processing unit of the toothbrush operates a capacitive touch

sensor that constantly monitors for a touch input, such as the user holding the toothbrush. The data processing unit of the toothbrush then transmits a signal at a certain frequency to the mobile unit using the human body as a capacitive coupler. The human body's capacitance allows it to transmit signals at different frequencies simultaneously as a capacitive coupler. Additionally, the mobile unit comprises a data processing unit. The mobile unit receives the signal from the toothbrush, base unit, indicating the user is in contact with the toothbrush and transmits a response signal at a different frequency than the signal sent from the toothbrush. The response signal identifies the mobile unit using a unique identification code, thus identifying the user to the toothbrush. Since the frequencies of the two signals differ, the signals can be sent simultaneously allowing for simultaneous identification of the user.

[0060] Optionally, the mobile unit is a data transfer medium, such as a "smartphone," comprising a data processing unit. The data transfer medium receives the signal from the toothbrush through capacitive coupling of the human body, and the data transfer medium transmits the user identification signal to the toothbrush through capacitive coupling of the human body. This configuration allows the toothbrush to identify the user via a "smartphone" the user is currently using.

[0061] Optionally, the mobile unit is a dedicated system that readily attaches to a data transfer medium and utilizes the data transfer medium's data processing unit. Accordingly, the dedicated system that readily attaches to a data transfer medium provides an interface to the human body for capacitive coupling. Optionally, the mobile unit is an activity tracker that is worn on the user's body. Optionally, the mobile unit is a wrist worn device such as a watch, bracelet, activity tracker, or any combination thereof.

[0062] Optionally, the mobile unit is a dedicated system that is used for the sole purpose of identifying the user. Optionally, the mobile unit is an embedded chip in the user's skin such that the user can consistently be identified by the toothbrush. Optionally, the mobile unit is a tattooed circuit on the user's skin such that the circuit can receive the signal from the toothbrush and transmit the user identification signal.

[0063] Furthermore, in some embodiments, the mobile unit that communicates with the toothbrush communicates with at least one other base unit such that the same mobile unit can be used with multiple base units that utilized capacitive coupling through the human body for user identification. Other base units may include scales, floss, activity trackers, refrigerators, bath mats, door handles, remote controls, computer input devices, and other various devices that require a user to touch them for proper use.

[0064] In some embodiments, the toothbrush with sensors and user identification including variations described herein is comprised in a system that allows a user to view and monitor the measured data via a data transfer medium, such as a "smartphone", and/or a network storage device, often known as the "cloud" and hereinafter referred to as the Cloud. Embodiments of the toothbrush comprised in this system include the data extractor described previously. Accordingly, the system allows the toothbrush to transfer data to the data transfer medium and/or the Cloud. Additionally, the data transfer medium may transfer said data to the Cloud for display and manipulation on further data transfer mediums connected to said Cloud. Alternatively, the Cloud may transfer said data to the data transfer medium.

[0065] In some embodiments, the data transfer medium comprises a receiver, a transmitter, a data processing unit, and a display. Accordingly, the data processing unit is chosen from the group microprocessor, microcontroller, field programmable gate array (FPGA), digital signal processing unit (DSP), application specific integrated circuit (ASIC), programmable logic, and combinations thereof. The data processing unit comprises a collector, storage medium, and a processor.

[0066] Moreover, the storage medium of the data processing unit is comprised of volatile memory and non-volatile memory, wherein volatile memory is used for short-term storage and processing, and non-volatile memory is used for long-term storage. Accordingly, in some embodiments, volatile memory is chosen from the group random-access memory (RAM), dynamic random-access memory (DRAM), double data rate synchronous dynamic random-access memory (DDR SDRAM), static random-access memory (SRAM), thyristor random-access memory (T-RAM), zero-capacitor random-access memory (Z-RAM), and twin transistor random-access memory (TTRAM). Optionally, in some embodiments, non-volatile memory is chosen from the group read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), flash memory, ferroelectric random-access memory (FeRAM), magnetoresistive random-access memory (MRAM), phase-change memory (PRAM), conductive-bridging random-access memory (CBRAM), silicon-oxide-nitride-oxide-silicon memory (SONOS), resistive random-access memory (RRAM), race-track memory, nano-random-access memory (NRAM), and Millipede memory.

[0067] Further still, the processor of the data processing unit is chosen from the group microprocessor and microcontroller.

[0068] Additionally, the receiver of the data transfer medium is chosen from the group universal serial bus (USB), serial port, wired Ethernet port, radio frequency, microwave communication, infrared short-range communication, near field communication, and Bluetooth. Often, the receiver of the data transfer medium receives at least one signal from the data extractor of the toothbrush.

[0069] Optionally, the data transfer medium is chosen from the group personal computer, tablet computer, mobile phone (i.e. "smartphone"), television, dedicated system, charging station, network router, and web-enabled server.

[0070] Optionally, the transmitter of the data transfer medium is chosen from the group universal serial bus (USB), serial port, wired Ethernet port, radio frequency, microwave communication, infrared short-range communication, near field communication, and Bluetooth.

[0071] Additionally, the display of the data transfer medium converts signals into user-readable formats.

[0072] In some embodiments, the Cloud is connected to a network, wherein the network is chosen from the group Internet or intranet such that an intranet is a network managed and accessed by an internal organization and is not accessible to the outside world. The network is utilized by the Cloud for receiving and transmitting data. The mode for receiving and transmitting data through the network is chosen from the group universal serial bus (USB), serial port, wired Ethernet

port, radio frequency, microwave communication, infrared short-range communication, near field communication, and Bluetooth.

[0073] Additionally, the Cloud processes data using at least one microprocessor, at least one microcontroller, or a combination thereof. The storage of data is comprised of volatile memory and non-volatile memory, wherein volatile memory is used for short-term storage and processing, and non-volatile memory is used for long-term storage. Accordingly, volatile memory is chosen from the group random-access memory (RAM), dynamic random-access memory (DRAM), double data rate synchronous dynamic random-access memory (DDR SDRAM), static random-access memory (SRAM), thyristor random-access memory (T-RAM), zero-capacitor random-access memory (Z-RAM), and twin transistor random-access memory (TTRAM). Optionally, non-volatile memory is chosen from the group read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), flash memory, ferroelectric random-access memory (FeRAM), magnetoresistive random-access memory (MRAM), phase-change memory (PRAM), conductive-bridging random-access memory (CBRAM), silicon-oxide-nitride-oxide-silicon memory (SONOS), resistive random-access memory (RRAM), racetrack memory, nano-random-access memory (NRAM), and Millipede memory.

[0074] The Cloud, optionally, is a network server primarily used for storing and processing data. Optionally, the Cloud is comprised of more than one network server such that the network servers operate in conjunction to increase the storing and processing capabilities of the Cloud. Alternatively, the Cloud is provided as a service such that it is physically located at a location separate from the user, and the service provided is the storing and processing of data.

[0075] In some embodiments, the system comprising the toothbrush facilitates the user's participation in social games related to the data collected by the sensors of the toothbrush. Participation in said social games is accomplished passively through the collection of data by the sensors of the toothbrush over a period of time, rather than participation by real-time user input. Optionally, the social games consist of goals to be accomplished, competitive games between multiple users or between a singular user and a computer generated user, and challenges to complete specified milestones.

[0076] Participation in social games is accomplished through a plurality of different user groups. The first user group for participation is a closed loop user group, which is accomplished on a specific data transfer medium and participation is limited to the users of said specific data transfer medium. The second user group for participation is a networked user group, which is accomplished over a network that connects a plurality of data transfer mediums. Networked user groups are further defined as including users belonging to a certain group defined through social media or other means. The third user group for participation is a global user group, which is a user group that anyone can join and participate in. The global user group, in some embodiments, may be sponsored or promoted by a particular entity as a form of advertisement or incentive to the users of the global user group.

[0077] Participation in social games may be incentivized with an offered reward to encourage participation of members of a user group. Rewards may include coupons, discounts on

goods or services, virtual currency, insurance discounts, and customized incentives. Rewards have the advantage of being given based off of passive data collected by sensors, thus rewarding users for health compliance and health statistics.

[0078] In some embodiments, the system and toothbrush provide for the user's active participation in real-time games using the toothbrush as a controller. Optionally, the game interface is comprised in the data transfer medium, such that it displays the interactions and provides the processing and storage means for the game. Additionally, games can encourage a user to complete proper brushing within the entire oral cavity and direct the user to move to underserved areas of the oral cavity through game interaction.

[0079] It will be understood that the embodiments described herein are not limited in their application to the details of the teachings and descriptions set forth, or as illustrated in the accompanying figures. Rather, it will be understood that a toothbrush and system with sensors and user identification, as taught and described according to multiple embodiments disclosed herein, is capable of other embodiments and of being practiced or carried out in various ways.

[0080] Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use herein of "including," "comprising," "i.e.," "containing," or "having," and variations of those words is meant to encompass the items listed thereafter, and equivalents of those, as well as additional items.

[0081] Accordingly, the descriptions herein are not intended to be exhaustive, nor are they meant to limit the understanding of the embodiments to the precise forms disclosed. It will be understood by those having ordinary skill in the art that modifications and variations of these embodiments are reasonably possible in light of the above teachings and descriptions.

What is claimed is:

1. A toothbrush, comprising:

- a handle having a brush head with a plurality of bristles;
- a data processing unit having at least one collector that is configured to collect data, a storage medium that is configured to store data, and at least one processor that is configured to process data;
- a transceiver that is configured to transmit and receive data; and
- a temperature sensor that is configured to measure body temperature of the user.

2. The toothbrush of claim 1, further comprising at least one additional sensor chosen from the group consisting of an orientation sensor, oximetry sensor, capacitive sensor, pressure sensor, and any combination thereof.

3. The toothbrush of claim 1, wherein the transceiver is chosen from the group consisting of a universal serial bus (USB), serial port, wired Ethernet port, radio frequency, microwave communication, infrared short-range communication, near field communication, Bluetooth, Wi-Fi, and any combination thereof.

4. The toothbrush of claim 1, wherein the temperature sensor is chosen from the group consisting of a thermocouple, thermistor, resistance temperature detector, infrared temperature sensor, thermopile, thermostat, silicon bandgap temperature sensor, and any combination thereof.

5. The toothbrush of claim 1, wherein the temperature sensor is at least partially located in the brush head.

6. The toothbrush of claim 5, wherein the brush head is detachably connected to the remainder of the handle.

7. A toothbrush system, comprising:

a toothbrush having a handle with a plurality of bristles on one end, a data processing unit that is configured to store and process data, a transceiver that is configured to receive and transmit data, and a temperature sensor that is configured to measure body temperature of the user; and

a cloud computing network having at least one data processing unit that is configured to store and process data and a transceiver that is configured to receive and transmit data.

8. The toothbrush system of claim 7, further comprising a data transfer medium having a transceiver that is configured to receive and transmit data, a data processing unit that is configured to store and process data, and a display that is configured to show data.

9. The toothbrush system of claim 7, wherein the toothbrush further comprises an additional sensor chosen from the group consisting of an orientation sensor, oximetry sensor, capacitive sensor, pressure sensor, and any combination thereof.

10. The toothbrush system of claim 7, wherein the data transfer medium further comprises a user interface that is configured to facilitate participation in social games such that participation is accomplished passively through data collection of the toothbrush over a period of time.

11. The toothbrush system of claim 7, wherein the data transfer medium further comprises a user interface that is configured to facilitate active participation in games, wherein the toothbrush is a game controller.

12. A toothbrush system, comprising:

a toothbrush that is configured to act as a base unit having a handle with a plurality of bristles on one end, a data processing unit that is configured to store and process

data and detect touch input from the user, and a transceiver that is configured to receive and transmit data;

a mobile unit having a data processing unit that is configured to store and process data and communicate with the toothbrush via capacitive coupling,

wherein both the toothbrush and the mobile unit are in contact with the human body such that the human body acts as a capacitive coupler and is arranged to allow for the transmission of at least one signal.

13. The toothbrush system of claim 12, wherein the toothbrush is configured to transmit a signal at a frequency that is different than frequency of the signal that the mobile unit is configured to transmit.

14. The toothbrush system of claim 13, wherein the toothbrush and mobile unit are configured to transmit signals simultaneously.

15. The toothbrush system of claim 12, wherein the toothbrush is configured to transmit a signal to the mobile unit when a touch input is detected.

16. The toothbrush system of claim 15, wherein the mobile unit is configured to transmit a response signal to the toothbrush.

17. The toothbrush system of claim 16, wherein the response signal further comprises at least one identification code.

18. The toothbrush system of claim 12, wherein the mobile unit is comprised in a data transfer medium.

19. The toothbrush system of claim 12, wherein the mobile unit is comprised in a dedicated system that is configured to detachably connect to a data transfer medium having at least one data processing unit and is configured to utilize the data processing unit of the data transfer medium.

20. The toothbrush system of claim 12, wherein the mobile unit is configured to communicate with additional base units.

* * * * *