Undeniable Commitment of Artificial Intelligence towards the Future of Periodontal Treatment- A Review

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Abstract: The abilityof machines to carryout tasks that ordinarilyrequire human intelligence is known as artificial intelligence. AI has been included into all dental specialties like periodontics, prosthodontics, endodontics, oral & maxillofacial surgery, etc. Most AI applications in dentistry are focused on diagnosing problems based on radiographic or optical images; other activities are less suitable than image-based jobs because of limitations in data availability, data consistency, and processing capacity to handle 3D data. In a similar vein, ongoing researchisconductedinthefieldofperiodonticstomeasurevariousaspectssuchasbonel oss and the quantity of plaque present. This review aims to help periodontists better comprehend AI as a tool to support their normal job with increased efficiency.

Keyword: Artificial intelligence, CNN, deep learning, machine

1. Introduction

The most remarkable organ in our body is undoubtedly our brain, which processes a wide range of experiences on a regular basis. Currently, a number of studies have developed different experimental concepts that illustrate the potential to imitate the human brain. Scientists have been developing artificial intelligence that mimics the behavior of real intelligence for many years. AI permeates every aspect of our daily lives. Our phones' artificial intelligence has become an indispensable part of our everyday existence.

Artificial intelligence is defined as “a field of science and engineering concerned with the computational comprehension which is commonly known as intelligent behavior, and with the creation of artifacts that show such behavior[1].”

AI has applications in both the virtual and physical domains i.e., robotics. The primary domain of the virtual type is the mathematical equations for medication interactions, digital health documentation, diagnosis and prognosis, drug dosage, and appointments [2].

The bulk of dental applications use supervised learning, in which the ground truth is determined and a huge number of samples with various attributes (photos of the patient, gender, age, number of cavities, etc.) make up the training data. By detecting periodontal alterations early, deep learning analysis utilizing radiographs can aid in the diagnosis and treatment planning of periodontal illnesses. This aids in implantology's early intervention. This technology not only advances our knowledge of periodontitis but also acts as a link between traditional indicators and immunologic and microbiological factors for periodontal diagnosis. Numerous research projects on artificial intelligence applications in periodontics are being conducted, or have already been implemented, in areas like illness prognosis, diagnosis, decision-making and treatment planning [3].The aim of this review is to highlight the importance of AI in the field of periodontics.

2. HistoryofArtificialIntelligence

AlanTuringwroteinhispaper"ComputingMachineryandIntelligence"inthe1950issueof Mind: "I believe that at the end of the century (20th), the use of words and general educated opinion will havealtered so muchthat onewillbeableto speak ofmachines thinkingwithout expectingto be contradicted [4]."Since there was no term for AI back then, Turing defined it as "machine thinking." He studied the viability of Artificial Intelligence statistically and investigated the creation and evaluation of intelligent devices [4].

3. Classification of Artificial Intelligence

Artificial Intelligence (AI) can be achieved in many ways, and different types of AI can performdifferenttasks. Scholarshave created numerousclassificationschemesforAI (Fig1) [5].

4. Can AI Practically Solve Periodontal Problems?

In periodontics, AI is still in its infancy. Since deep learning was introduced, there has been an increase in interest in research and development connected to AI. Among the dental AI tools are devices that let periodontists remotely review photos of the mouth cavity that patients send via smartphone. Patients can capture images of their teeth with AI-guided imaging devices, which can then be used to recognize any signs of poor oral health and communicate them to the periodontal team [5]. It is important to keep in mind that artificial intelligence is a type of assistance rather than a decision-maker.

5. How do AI models work?

"Training" is the initial phase of AI functioning, followed by "testing". The parameters of the model set are determined by the training data. The model makes use of data from prior instances, whether patient data or data from data sets containing various examples [6].

6. Abrief highlight on application of AIindentistry

In dentistry, diagnosis is the most common usage of Artificial Intelligence (AI). AI can diagnose illnesses more rapidly and precisely, saving dentists time and effort. On the one

hand, computers are starting to playa bigger role in the decision-making process for dentists. On the other hand, the reliability, accuracy, and intelligence of dental computer system is increasing [7,8]. Nowadays, research on AI is being done in everyaspect of dentistry (Fig 2). While the benefits of artificial intelligence in providing second opinions and enforcing consistency are obvious, additional uses, such as combining patient and practice data with dataon diagnosis and treatment outcomes, will eventuallycreatenewoperatingstandardsand standards of care. New types of data linkage—dental, genetic, geographic, demographic, and medical—willenable AI todelivertruly revolutionary andpotentiallylife-savingvalueby creating new connections between systemic health and dental health once it is firmly established as a tool in care and practice management.

7. Role of Artificial Intelligence in Periodontics

AI has many uses in dentistry, including the upkeep of patient records, risk assessment and prediction, early detection and screening, diagnosis and monitoring of disease, and dental teaching and training.

Severe cases of periodontitis must be avoided by early detection and treatment. Gingival recession and pocket probing depths are utilized in clinical practice to diagnose periodontal disease. Clinical attachment loss is commonly measured using the Periodontal Screening Index (PSI) [9]. To maintain periodontal health, advanced diagnostic and screening methods—which primarily entail a thorough periodontal examination—must be extensively used. In addition to clinical examinations, a range of imaging modalities are used to support dentists in identifying periodontal disorders and tracking the effectiveness of treatment [9].

Toautomaticallyidentifyteeththat areperiodontallydamaged, Lee *etal*.assessedtheuseand accuracy of a suggested CNN algorithm [10]. Yauney *et al*. assessed the potential use and accuracy of a suggested CNN algorithm [11].

Hapticsbasedvirtualrealityperiodontaltrainingsimulator

The term "haptics" describes the field of robotics and virtual reality (VR), which includes simulationtoolsfortouch-relatedsenseslikevibrationandpressure. Usinghapticdevicesin conjunction with dental simulators, users can manipulate, feel, and operate on both soft and hard tissues using their tactile sense. A haptic device is a mechanical device that enables information exchange or two-way connection between the user and a virtual environment [12].

Haptics-based simulators, which use virtual representations of a human tooth or mouth, combineahapticdevicewithadentalpracticeplatform.Insteadofusingactualdental instruments, the learner can use virtual ones byholding the stylus of a haptic device (Fig 3). This produces tactile input that replicates clinical sensations in the operator's hand. Using these Virtual Reality (VR) simulators has the benefit of giving surgeons the chance to continually rehearse operations or surgeries at no added cost [13].

Using one of the two visuo-haptic systems—**PerioSim**and a **periodontal simulator**—one

can develop the competence necessary to diagnose, treat, and distinguish between problematic and normal situations. **University of Illinois at Chicago** developed PerioSim and the Periodontal Simulator. The program can be used to teach students about different facets of periodontology by simulating three dental instruments: a periodontal probe, a scaler, and an explorer [14].

Rowe *et al.* conducted a study which indicates that training on simulators has notably improved students'proficiency and output on patients when compared to those individuals who were untrained [15].

Steinberg *et al*. observed that the 3D images of the virtual mouth and instruments were considered highly realistic. Furthermore, the gingiva had less realistic tactile sensation than the teeth and equipment.The experiment's findings demonstrated that the prototype haptics-based periodontal simulator was sufficiently lifelike to be a valuable teaching aid with significant potential for teaching periodontal treatments [16].

Artificially intelligent of faction in halitosis

The ab ility to detect and differentiate between different environmental components in the air is attributed to the olfactory sense. Because it reduces olfactory input, anosmia—which has becomemorecommon duringtheCOVID-19 pandemic—can seriouslylowerone's qualityof life. The sense of smell is produced by odorant receptors in the nasal canal, which identify odorants and send neural signals to the brain for processing [17].

The production of Volatile Sulfur Compounds (VSCs) by oral bacteria is facilitated by oral halitosis. VSCs are the most prevalent sign of halitosis because they are very volatile and have a low threshold for odor. Nevertheless, there are drawbacks to depending only on VSC detection for diagnosis, as halitosis can also be caused by other illnesses and some volatile non-sulfurcompounds whenVSCsareabsent.Theorganolepticapproach, whichassessesthe level of unpleasantness in the air exhaled from the mouth and nose, is still the standard or traditional method for diagnosing halitosis. A method known as artificial olfaction has been developed to overcome these drawbacks [18].

Anon-invasivetechniquecalledartificialolfaction assesses veryvolatilecompound breathed. It is made up of a range of sensors, most of which are based on nanomaterials, that analyzethecompositionofexhaledairsemi-selectivelyorcollectivelyusinganalytic software and adatabaseofbreath patternsbefore processingthedatafora pattern-recognition application (Fig 4). Next, a decision tree classifier determines if the patient has oral or extra- oral halitosis; in the case of the latter, it can also create links to other systemic illnesses [18]. Khatoon*etal.*DopedCoandNiwithtinoxide(SnO_2)usingasol–gelmethodand investigated it as a sensor material for e-nose development. Using cyclic voltammetry, theyemployeda screen-printed electrode based on MO as the working electrode to measure theconcentrationsof1-propanolandisopropylalcohol.Moreover,amongtheotherexamined volatileorganiccompounds(VOCs)(acetone,toluene,formaldehyde,2-butanol,andethyl acetate),Ni-$SnO_2$and Co-SnO_2werefoundtobeselectiveto1-propanolandisopropyl alcohol,

respectively [19].

Liu *et al.,* in order to detect acetone gas, built a variety of CeO2-based gas sensors and connected them to several MMnO3 (M: Sr, Ca, La, and Sm) sensing electrodes. They then carried out comparative research. A straightforward sol–gel technique was used to create the CeO2-MMnO3 molecules [20].

Diagnosis and prediction of period on tally compromised teeth

The mechanism for identifying and predicting Periodontally Compromised Teeth (PCT) has not significantly improved despite advancements in treatment modalities. Conventional periodontalexaminationsuseperiodontalprobesandpanoramic/periapicalradiographs, whichis world widely used as diagnostic tools. However, since roughly 2010,ConvolutionalNeuralNetworks,thenewestcoremodelofartificialneural networksanddeep learning in computer vision, have developed rapidly [21]. Medical data is digitally saved and accumulated both quantitatively and qualitatively, making the periodontal area ripe for the application of Deep CNNs with Computer-Aided Detection (CAD) systems. In terms of diagnosis and prediction in radiological and pathological research, this quickly developing field of study has yielded remarkable results [22].

Chen *et al.*proposed 3 post-processing techniques to supplement the baseline faster R-CNN according to certain prior domain knowledge. Initially, a filtering method was created to eliminate overlapping boxes—that is, boxes linked to the same tooth—that the quicker R-CNN identified. After that, a neural network model was used to identify teeth that were missing. Intheend,arule-basedmodulebasedon ateethnumberingsystemwassuggestedin order to match the labels of teeth boxes that were found and change the outcomes that were found to be in violation of specific intuitive rules [23].

Tuzoff*et al.*showed howaquickerR-CNN model could be trainedto identifyand categorize teeth on panoramic radiographs according to tooth number, with potential uses in automated dental recording. The quicker R-CNN's performance was on par with experts'[24].

8. Applications of Artificial Intelligence in Implantology

Around the past few decades, implant dentistry has developed rapidly all around the world. Dentistry has seen a transformation because to implantology, particularly in terms of patient rehabilitation for those with single, partial, or total edentulism. There is a sufficient body of literature describing how implant treatment improves a patient's overall quality of life. Implant survival and success rates have increased thanks to ongoing research and advancementsintechnology.However,therehavebeenanumberofdifficultiesassociated with the improvements in this sector, including prosthetic complications, super-structure or implant concerns, and peri-implantitis [25].

AI has been utilized more frequently in periodontology and implant dentistry in recent years to expedite dental operations and enhance patient outcomes. Using artificial intelligence in

digital 3D treatment planning to match intraoral 3D pictures with CBCT data in software for surgical evaluation and planning is one way that AI is being used in implant dentistry. The software available now allows for precise 3D planning based on the preferences of practitioners. AI can help with implant planning by analyzing a patient's CBCT and intraoral scan data to identify the best site for the implant, lowering the possibility of surgicalproblems and increasing implant success rates [25].

Revilla-Leon *et al*. investigated the usefulness of AI models in implant dentistry for implant type detection, implant success prediction based on patient risk factors and ontology criteria, and implant design optimization that makes use of AI models in combination with finite element analysis computations [26].

In the future, radiographic imaging data and CBCT scans could be combined in implant dentistry to improve data processing and recognize implant types more accurately. Building and refining AI models for implant dentistry applications could be made simpler by utilizinga special class of deep learning techniques called 1-shot learning and less-than-1-shot learning. These techniques require fewer data points than neural network models [27].

Does AI Aid in Implant Surgery for Robotics?

The term "dentronics" refers to the fusion of AI and robots in dentistry. Accurate surgical positioning of a dental implant is necessary to avoid problems during the prosthetic and surgical processes. The robotic surgical assistant was given FDA approval in 2017 to be used inimplantinsertionprocedures.ThedentistplanstheimplantpositionbasedonCBCTscans, and the robotic arm executes the surgery as the dentist watches in real time, allowing the doctor the flexibilityto adjust any angulations during the treatment. In one instance, a patient in China had two implants inserted by a robot in 2017 without the dentist's assistance. Numerous clinical studies describing the successful implantation of implants by robots have been published in the literature [28].

Robotics in implant surgery can arise with the use of artificial intelligence. AI can optimize the implant process by analyzing big patient datasets to aid in diagnostic and treatment planning.

9. Chat GP Tin Periodontics

When it comes to speed, precision, and decision-making efficiency, AI is remarkably effective. Globally, ChatGPT (OpenAI, San Francisco, CA) is an AI chatbot with enormous ramifications for society. Its primary benefit is that it allows for interactive user dialogue, which is very useful in a variety of scientific and medical applications. OpenAI created ChatGPT-4, a last-generation language model built on the "Generative Pre-Trained Transformer (GPT)" architecture [29].

The emergence of the internet and the consequent growth of search engines featuring extensive language models have had a notable impact on the availability of patient data

related to health. Patients can find the answers to their medical questions via ChatGPTinstead of browsing through multiple websites. ChatGPT provides a lot of advantages, but it also has some significant drawbacks. Because of ChatGPT's excessive self-confidence, it can be challenging to verify the veracity and completeness of its information[29]. In order to earn consumers' trust, ChatGPT needs to demonstrate medical knowledge and judgment on par with human performance.

AI-driven chatbots in periodontology may prove to be helpful tools for practitioners and residentswhoneedquickaccesstoknowledgeanddirection.Thesemodels can helpwitha number of activities, including delivering evidence-based suggestions in response to clinical concerns and interactive learning opportunities [30]. AI chatbots, for instance, might save residents time and effort by rapidly retrieving information regarding periodontal disease categories, treatment regimens, and medicine dosages without requiringthem to seek through textbooks or internet resources. Furthermore, by offering simulated patient situations and assisting users in the diagnosis and treatment planning procedures, these models maysupport case-based learning.

Bizzi*etal*.assessedthequalityof gumdiseasematerialon theWebbased on standardssetby the Journal of the American Medical Association. Consequently, they demonstrated that Google may employ websites with excellent content for patient education [31].

10. Influence of AIon Periodontists

Though it is currently unknown if artificial intelligence (AI) can ever completely replace periodontists, there is a lot of talk about how AI will change the discipline of periodontics. Dentistryperformed by machines without human interaction does not constitute clinical care. Amachinecannot replacetheethereal perception, clinical intuition, and empathyrequired for skilled and customized healthcare delivery. The most fascinating aspect of human-to-human communication is challenging to translate into computer language [31].

11. Ethical Aspects of AI

AIin periodontics has a bright future, but therearechallenges and ethical dilemmas that need to be addressed. These include algorithm bias, data privacy, ongoing professional training, and regulatory compliance. To ensure that patient care remains at the forefront of this endeavor, academics and periodontists working with AI systems must collaborate on these concerns.ThedentalAImodelsareoverfittedandhavequestionablegeneralizabilitywhen examined more closely. It is essentialto set upamechanism to monitor open AIresearch and control the quality of AI software [32].

Future periodontal research must concentrate on early lesion detection that is invisible to the human eye in addition to raising AI models' performance to expert levels [33].

12. Conclusion

This paper goes into great detail about the use of Artificial Intelligence (AI) in periodontal care, focusing on how it has transformed patient monitoring, diagnosis, treatment planning, and education. The outcomes demonstrate the significant contribution AI may make to enhancing the efficacy, efficiency, and personalization of periodontal treatments. There are still many challenges ahead, but it will be valuable to go past them in order to reducemistakes and improve dental offices' proficiency in treating a variety of ailments. In order to broadenthe applicationarea andcompetence,moresystematicreviewsand meta-analysesare desperately needed, especially considering how swiftly artificial intelligence is developing in the periodontal field.

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Legends

Fig1: Classification of Artificial Intelligence Fig 2: AI in dentistry
Fig3: Simulator setup and handling there alinstrument and the hapticstylus

Fig4: Artificially intelligent olfactioninhalitosis

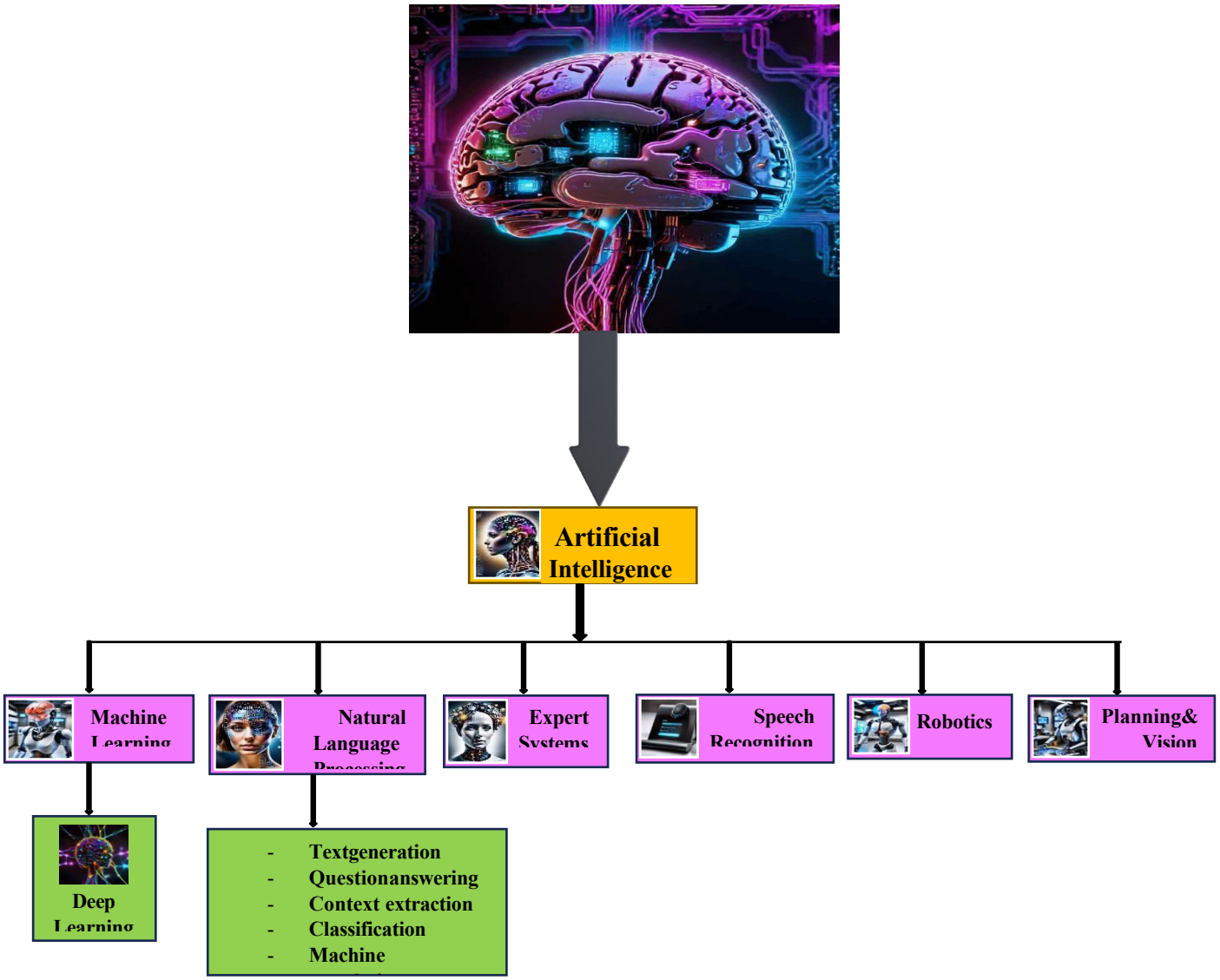

Fig1: Classification of Artificial Intelligence[5]

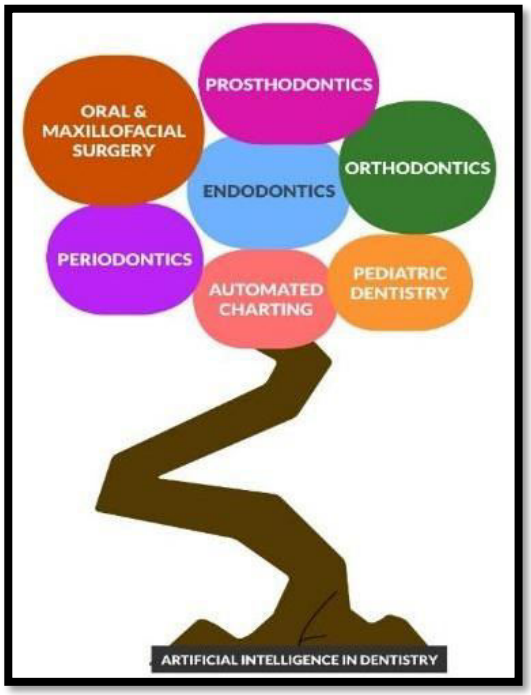

Fig2:AI in dentistry

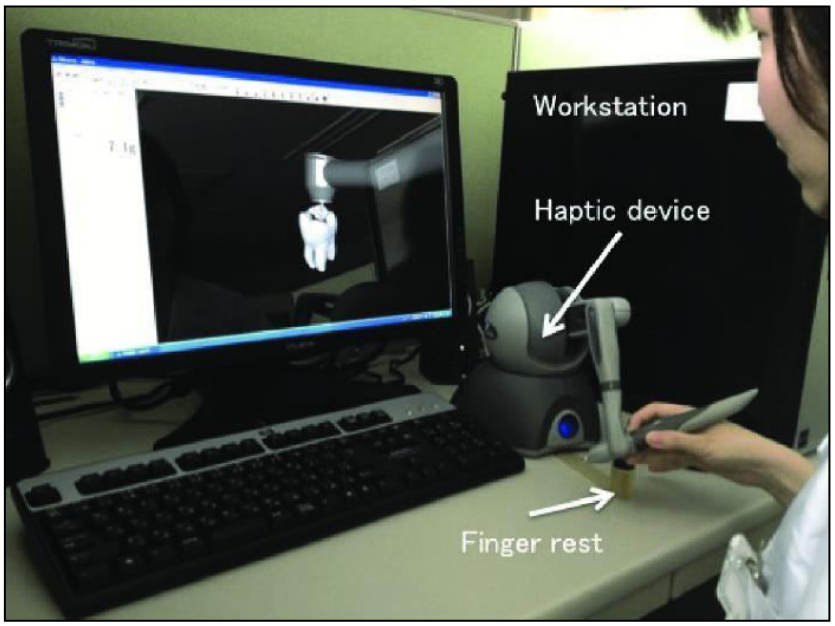

Fig3:Simulatorsetupandhandlingtherealinstrumentandthehapticstylus[14]

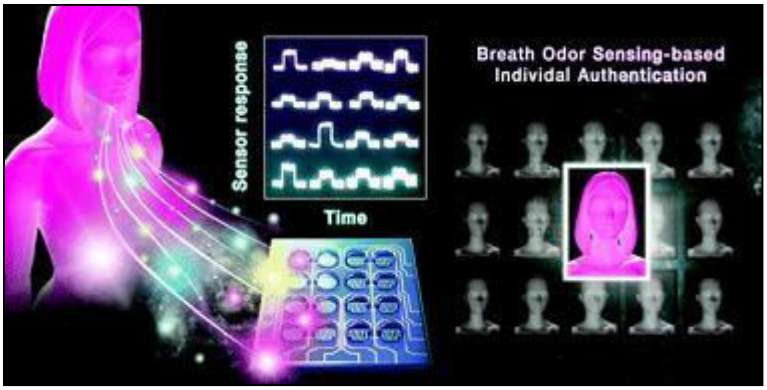

Fig4:Artificiallyintelligentolfactioninhalitosis[18]