ARTIFICIAL INTELLIGENCE TRANSFORMING PROSTHODONTICS

Abstract

The global excitement is palpable as artificial intelligence (AI) plays a pivotal role in shaping the future of humanity across engineering and healthcare domains. AI stands at the forefront of cutting-edge revolutions like big data, robotics, and IoT, and its role as a technological innovator is set to persist. Within dentistry, AI has significantly transformed prosthodontics, revolutionizing patient diagnosis, treatment planning, and the utilization of biocompatible substitutes like implants for replacing missing teeth. This review delves into the promising prospects and insights into the future of AI in prosthodontic practice.

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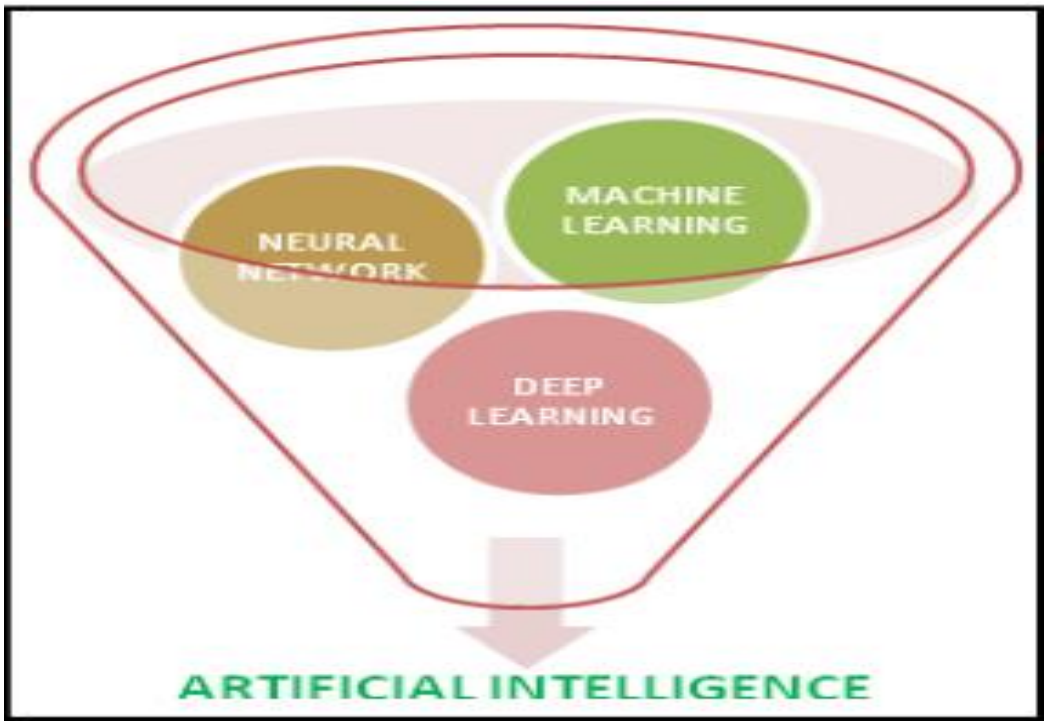
I. INTRODUCTION AND BACKGROUND

In today's rapidly digitizing world, technology has revolutionized various aspects of life, including dentistry, greatly improving the quality of care.1 While humanity has long been intrigued by the complexities of the human brain, the dream of creating a machine that can truly think like a human persists.2 Over time, extensive efforts have been made to replicate human brain functions, resulting in the development of artificial intelligence (AI). AI is the field that deals with the computational understanding of intelligent behavior and the creation of artifacts that exhibit such behavior.3 Its applications extend to telecommunications, aerospace, and now, the medical and dental domains.4

The availability of vast healthcare data has facilitated the emergence of AI in healthcare and dentistry, offering decision support systems to navigate clinical complexities and enhance diagnostic accuracy. With the advent of cloud computing and the accumulation of massive datasets, AI has gained momentum in dentistry, particularly in prosthodontics, orthodontics, oral surgery, and periodontics for condition analysis and treatment planning.5

II. KEY ASPECTS OF ARTIFICIAL INTELLIGENCE



1. **Machine Learning:** With machine learning, computers can infer their own rules by using advanced algorithms.6 Machine learning is used in e-commerce, automobile, internet search, sensor, robotics, speech recognition, image recognition, etc.

   Machine learning is subdivided into four categories of learning -

   - **Supervised Learning:** The computer has a tracing data set which is correctly labeled by a human expert.

- **Unsupervised Learning:** The computer does not use a tracing data set, but it tries to take up the data without human guidance separating the data into clusters or groups.

- **Semi-Supervised Learning:** It is not easy to supervise every dataset so when a large amount of unlabelled data is combined with a small amount of labeled data the accuracy of machine learning can be improved.

- **Reinforced Learning:** According to Hal Varian, it is a form of sequential experimentation of a computer in an attempt to achieve a goal while interacting with a dynamic external environment.7

2. **Neural Network:** As the name suggests, it uses artificial neurons to set the algorithm .it works almost similar to the human brain.

3. **Deep Learning:** It is a type of machine learning that utilizes the network with different computational layers to analyze the input data. Deep learning is also known as a conventional neural network.

III. ARTIFICIAL INTELLIGENCE AND PROSTHODONTICS

Prosthodontics, a dental specialty focused on oral function, appearance, and health, has embraced AI in various aspects of diagnosis, treatment planning, and prosthesis fabrication.8

AI is significantly contributing to the field

1. **Removable and Fixed Prosthesis**: AI advancements support digital impression-taking and intraoral scanning methods for the precise fabrication of removable and fixed prostheses. These technologies, including 3D face tracking, offer alternative treatments compared to conventional methods while maintaining a cautious approach due to evolving clinical settings.9

2. **Implantology:** AI's application in implantology opens doors to resolving limitations of fixed and removable prostheses. Implants offer improved resistance to dental diseases and enhanced support for various cases, with AI-assisted classification systems increasing accuracy in implant analysis.10

   The study conducted by Lee J and Jeong S utilized a convolutional neural network (CNN) to classify implants using panoramic and periapical radiographs. The findings of this research suggest that the deep CNN model can serve as a beneficial tool in categorizing implant systems with nearly equal or even superior accuracy compared to human classification.11

3. **Maxillofacial Prostheses:** Maxillofacial prostheses, used for cosmetic and functional rehabilitation, benefit from AI's advancements, including non-contact 3D laser measurement systems and improved retention methods like implants and adhesives. Digital technologies are enabling the efficient fabrication of these prostheses.12,13

The efficacy of any maxillofacial prosthesis hinges on its retention, significantly contributing to patient comfort and confidence. Multiple methods are employed to enhance retention, including the use of adhesives, implants, eyeglasses, and combinations thereof. There have been notable advancements in adhesive techniques and materials for securing maxillofacial prostheses.14

In recent years, Osseo-integrated implants have been increasingly utilized to improve retention in craniofacial areas. Various systems available in the market, such as bar and clip systems, magnets, mushroom attachments, and ball retention methods, serve the purpose of enhancing retention.15

Moreover, contemporary prostheses are now fabricated utilizing digital technologies, marking a significant advancement in their production.16,17

The fabrication process of maxillofacial prostheses using CAD/CAM technology begins with imaging techniques that capture both the patient's soft and hard tissues. Subsequently, specialized software processes this data, converting it into a Rapid Prototyping (RP) model. This RP model is then used in reproduction techniques, where it's translated into wax directly or within acrylic resin. Ultimately, the silicone elastomer prosthesis is crafted from the resulting cast.18,19,20

This approach significantly reduces the time required for fabrication compared to traditional methods.

4. **Computer-Aided Designing and Computer-Assisted Manufacturing (CAD-CAM):** CAD-CAM technology, utilizing digital impressions and scanners, enables the design and fabrication of prostheses, addressing the limitations of conventional impression materials. This technology streamlines the process, resulting in precise and patient-specific prostheses.

Certainly, the CAD-CAM (Computer-Aided Design and Computer-Aided Manufacturing) system is comprised of three main components:

- **Digital Impressions/Scanners:** Traditional methods for recording prepared teeth and adjacent dental tissues through impression techniques have limitations owing to various drawbacks in impression materials. The field of material science has yet to produce a universally ideal impression material suitable for all dental procedures. To address these limitations, intraoral scanners have been developed leveraging technological advancements to overcome the drawbacks associated with conventional impressions.21

- **Designing the Final Prosthesis:** Once the dentist provides the scanned impression of the prepared tooth, data is then processed using design software in the laboratory. This software enables the creation of a final three-dimensional image resembling a provisional restoration. The designed final prosthesis can be sent to the dentist for approval, allowing modifications if necessary. After finalizing the design, the data is transmitted to a specialized milling device.22

- **Milling Phase:** Following the completion of the design phase, the data is sent to a centralized milling or production center. Here, suitable restorative materials can be milled using additive, subtractive, or 3D printing techniques.23

IV. CONCLUSION

Artificial intelligence has undeniably transformed dentistry and prosthodontics, providing valuable support for clinicians. However, it is important to recognize that AI complements human expertise but cannot replace the knowledge, skills, and judgment of healthcare professionals. While AI is a powerful tool, it remains a testament to human innovation and ingenuity in the quest for better healthcare.

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