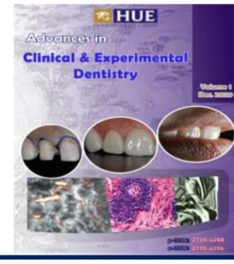
Advances in Clinical and Experimental Dentistry



Short Communication

State of the art computational applications in experimental and clinical dentistry

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The interoperability between computer applications and medicinal sciences has helped achieve stunning diagnostic advances. In experimental and clinical dentistry, computational integration has been incorporated into basic sciences, orthognathic surgery, oncology, radiology and imaging, prosthodontics, and restorative dentistry. The use of computational applications includes building e-health records, assessing health informatics, knowledge retrieval, modeling and simulation, supporting diagnostic decisions, and robotics [1-5]. This article provides a bird's eye view of recent breakthroughs that have benefited from computational algorithms and that offer insights into potential future progress in understudied areas of research.

The seven most frequently used algorithms are artificial deep convolutional neural networks, k-nearest neighbor, Naive Bayes, decision tree, support vector machine, random forest, and logistic regression algorithms. Applications of these algorithms have introduced several outputs including U-Net, AlexNet, and the GoogLeNet Inception v3, CNN network, Web-available STRING software, the GPU training system (DIGITS), and DetectNet [6-16].

In basic sciences, computational applications are useful for conducting image analysis. Images are usually imported from microscopes for processing using various user-friendly software programs such as ImageJ (with its numerous plugins), Optika Proview and DiversePathsJ. Data analysis can then be utilized for multilevel logistic modeling, path analysis and structural equation modeling to replace single-level techniques for the analysis of hierarchical dental data [17-22].

In orthognathic surgery, virtual surgical planning is used in orthognathic surgery to reconstruct defected jaws with a vascularized free osseous flap, to fix fractured craniomaxillofacial bones, to plan alloplastic temporomandibular joint replacement or to reconstruct condyles in patients with bilateral ankylosis of the TMJ. After building a scannographic template and performing a high-resolution helical computed tomography (CT) scan, collated data are imported into Mimics 10.01 software (Materialise, Leuven, Belgium) to construct 3D skull models using a rapid prototyping device before surgical planning with SurgiCase CMF software (Materialise, Leuven, Belgium) [23-29]. The

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Computational Fluid Dynamics (CFD) model is also customized to simulate the upper airway to treat obstructive sleep apnea and to improve ventilation in the nasal airway after maxillary expansion or maxillomandibular advancement [30-34]. In endodontics, the CFD model is widely used to assess the efficacy of irrigant flow in the endodontic treatment of root canals using different needle types, especially tapered canals. The CFD model is also used to evaluate positive pressure and apical negative pressure associated with conventional versus passive ultrasonic irrigation dynamics [35-40]. The efficiency of several different irrigation systems in cleaning mandibular root canals and isthmuses of human molars have been assessed by capturing images with a stereomicroscope and using ImageJ for analysis.

Future applications of the CFD model are expected to nourish the domain of vascular oncology. The integration of MRI, MRA, angiograph and Doppler interrogation imaging studies could be tethered to CFD-based software to explore the best surgical interventions to treat high-flow hemangiomas and vascular malformation by selective occlusion of feeding vessels. The precision of biomedical image analysis could be enhanced when appropriate algorithms are applied to the indicated imaging technique [41-44].

Stereolithography and the placement of dental implants also provides a realistic and accurate forecast of the patient's facial appearance after surgery. Furthermore, many computational algorithms have been used to assess temporomandibular internal derangements. A 23-13-1 Back Propagation, ANN model was constructed to determine the validity of extracting premolars before orthodontic treatment [45].

For oral oncology, molecular modeling and genetic mapping would not be as advanced without computational effort. For example, GoogLeNet Inception-v3 architecture was used to diagnose odontogenic cystic lesions. In addition, several algorithms use optical tools and retrieve DICOM images to detect precancerous lesions from clinical pictures or radiographs. Furthermore, pre-scaled and annotated data have been used to train histopathologic classifiers [46-47]. Finally, DetectNet with DIGITS v.5 has been used to evaluate extranodal extension metastases into lymph nodes in patients with squamous cell carcinoma [48-51].

Computational applications in maxillofacial radiology and imaging are the most significant. In addition, advancements in computers and imaging have permitted the adoption of 3-dimensional imaging protocols in the healthcare field. Image fusion involves the combination of images from different imaging modalities to create a virtual record of an individual, which is called a patient-specific anatomic reconstruction. This also reduces working time, allows for a lower radiation dose for the patient, requires fewer retakes and errors, and allows a wider dynamic range, easier access to patient information and easier image storage and communication over conventional imaging modalities. These gains come at a very low cost, but patient discomfort, damage to the receptor, degradation of the image, cross-contamination, and viewing conditions are the most common drawbacks discussed in the literature [52]. Recent uses include applying MedView, which is a computer program based on formalized input and registration of all clinical information, toward education and distance-based consultations [53].

Prosthodontics and restorative dentistry began to benefit from computational applications (building software programs) even before the introduction of CAD/CAM, oral scanners and intraoral optical impression systems. The Logicon Caries Detector™ (LDDC) and U-Net were introduced to detect and diagnose early proximal caries detection in digital bitewings [54], while other AI-based algorithms predict debonding of CAD/CAM composite resin. New programs now evaluate the severity of periodontal diseases [55]. Proposed as a noninvasive imaging tool, optical coherence tomography was originally used for the diagnosis of ocular and skin lesions. Later, it was utilized in periodontology because it demonstrates fine microstructural detail that enables the visual recording of periodontal tissue contours, sucular depth and the attachment of connective tissue [56]. The application remains most successful in oral radiology [57-62].

The limitation of the computational applications of data is attributed to a paucity of available medical data, the incompatibility of research teams, and a lack of giant open-source streams and libraries. Because the use of patients' data requires informed consent, the processing of large-scale data remains a great obstacle. A lack of coherence inside the research group also complicates matters. In addition, several biomedical research projects have been implemented by engineers without consulting any medical personnel. To some extent, the output of such studies is considered pseudoscience. Furthermore, building a team of paramedics without taking advantage of the clinical and surgical data is even worse. After publishing a computational research paper, many authors retain the modified algorithm and do not share the data collated to retrieve their studies. The interoperability between various domains is not possible without the integration of intellectual efforts among experts and institutions.

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