Machine learning literacy for orthodontists

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As someone who has been supervising orthodontic residents for nearly a decade, you enjoy engaging in academic conversations regularly. You especially relish Thursday mornings, a journal club day in the department, where you can have an in-depth conversation with residents regarding the latest research in orthodontics and in so doing keep abreast of the recent developments. Over the past few months, you have observed a recurring trend in orthodontic research - the increasing use of Artificial Intelligence (AI). Just last week, the use of neural networks for cervical vertebral maturation staging was discussed in the journal club and as a first-year resident starts another journal club highlighting the predictive accuracy of a machine learning model in orthodontic treatment planning, you are convinced that machine learning has well and truly become an integral component of orthodontics.

AI refers to the ability of machines to perform tasks that would normally require human intelligence. According to Andrew Ng, a world authority in deep learning, AI is the new electricity and it is here to revolutionize the world like electricity did in the 19th century.[1] While terms like AI, machine learning, and deep learning are often used interchangeably, there are subtle differences among them. Machine learning is a branch of AI that employs algorithms (sets of instructions or rules) capable of learning from data to make predictions.[2] While, Deep learning, a specialized branch of machine learning, utilizes algorithms that learn tasks by processing data through multi-layered neural networks, enabling computers to make decisions autonomously.[3] Simply put, machine learning is a subset of AI, and deep learning is a subset of machine learning. Although the concept of machine learning dates back to the 1950s, it has truly come to life in the last two decades, fueled by the surge in big data and advancements in computers' processing capacity. It is fair to say that the current enthusiasm for machine learning is largely driven by significant achievements in deep learning techniques, particularly in areas like image recognition and natural language processing.

Machine learning algorithms learn through two main approaches: supervised learning and unsupervised learning, distinguished by the nature of the data involved during the training process. Supervised learning, unlike unsupervised learning, utilizes labelled data for training, where both the input and the output are known. When it comes to supervised learning, it is similar to teaching a child how to differentiate between cats and dogs by showing them labelled photographs. Once the child has completed this training, they will be able to proficiently identify cats and dogs when presented with a collection of photographs. On the other hand, unsupervised learning is similar to allowing a child to explore a diverse collection of animal photographs independently, encouraging them to identify patterns or similarities without specific guidance (unlabelled data). In general, supervised learning models are applied to tasks involving classification and prediction, whereas unsupervised learning is specifically employed for clustering tasks.

Convolutional Neural Networks (CNNs) are a type of deep learning algorithm commonly used in computer vision for image analysis and have been extensively used in orthodontics. Some of the common examples include tasks such as automatic landmark detection on lateral cephalograms and classification of cervical vertebrae maturation.[4,5] When presented with cephalometric images, the CNNs' initial layers automatically extract essential features, including edges and shapes associated with landmarks. As the network advances through deeper layers, it fine-tunes the localization of each landmark based on the extracted features. Ultimately, the final layer produces predicted coordinates for each landmark on the original image. However, a deep learning model's prediction may not be entirely accurate. The discrepancy between the predicted value and the actual value (Ground truth) is called loss - the lower the loss, the more accurate the model. Model development is an iterative process, and eventually, the goal of training a deep learning model is to minimize the loss. This is achieved through an iterative process called optimization, where the model's parameters (weights and biases) and hyperparameters

(learning rate and number of deep layers) are adjusted based on the calculated loss to develop a more accurate model.

From filtering spam emails to propelling self-driving cars, machine learning has come a long way and more importantly it is here to stay. Machine learning is transforming every aspect of human lives for the better, healthcare industry is no exception. Thus, machine learning literacy is crucial for orthodontists to stay relevant in their field.

By the time the journal club wrapped up, an intriguing research idea had germinated in your mind: using machine learning to revolutionize orthodontic diagnosis and treatment planning, that could potentially materialize as a thesis for a new resident. However, as you explore the topic further, you find yourself out of depth. You soon realize that having a basic understanding of statistics and programming concepts is foundational to implementing machine learning. You wonder, while you can still brush up on your statistical acumen, whether it is too late to start coding in Python. Don't hesitate; let the wisdom of a Chinese proverb guide you: "The best time to plant a tree was 20 years ago. The second-best time is now".

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