LETTERS TO THE EDITOR

Response to Editorial "Artificial intelligence, machine learning, and the human interface in medicine: Is there a sweet spot for oral and maxillofacial radiology?"

To the Editor:

I read with interest the recent Editorial by Dr. Aditya Tadinada concerning the potential role of artificial intelligence (AI) in health care and specifically in oral and maxillofacial radiology (OMR).[1] The purpose of this letter is to explain the barriers that must be overcome for AI to become a widespread clinical tool in OMR. My research experience in the development of image recognition algorithms and demonstration software systems since 1980 gives me a unique perspective regarding the tools that are needed to create an accurate "virtual oral and maxillofacial radiologist" through AI because I believe this is the ultimate goal.

Contrary to current belief, "deep learning" using neural networks by themselves will not be sufficient to develop accurate classifications for image-based diagnostic systems. Even the interactive labeling of important anatomic structures by human operators (people using a mouse to click on a point in an image and attaching an English description to it) in thousands of training images will not be enough. Why do I say this? Vision recognition is not a passive process but requires the use of a lot of contextual knowledge (e.g., a chair usually has four legs but when viewed from some directions may appear to have only 3 or 2). In fact, vision recognition has been described as a process of controlled hallucination.[2] As you look at an object, your brain extracts lines and shapes and then attempts to match these image features against stored models in the brain. When there is a match, you magically "see" the object. The ease of "seeing" depends on a huge database of models in the brain, constructed over years of observing the world. In the 1980s, expert system programs for diagnosing diseases were thought to require relatively small collections of a few hundred rules and facts about what constitutes a set of diseases or problems. With a small group of dental diseases, say 10, it was possible to correctly identify the conditions 70% to 90% of the time. However, as the number of diseases increased, accuracy rates fell. In the 1980s, Professor Douglas Lenat, then of Stanford University, realized that automation of intelligent tasks over a *wide* field would require gigantic knowledge bases akin to those in people's brains. He founded a company in 1984 initially to construct the knowledge base of a 3-year-old child. By 2017, the database had grown to contain 1,500,000 terms or facts about the everyday world that would be needed in solving a variety of problems.[3] Something similar to this will be required to successfully interpret the images that are recognized by "deep knowledge" systems. To give a specific example, recognizing that there is a dark patch interproximally on a bitewing radiograph and looking at the apparent depth into enamel or dentin is not sufficient to classify a carious lesion as one that requires restoration. There is need for additional knowledge about how shadow depth varies with x-ray beam direction and how to use the degree of interproximal overlap as a guide for estimating false carious lesion depth.[4] The process requires far more contextual information than one would think. For this reason, we can expect to produce the AI equivalent of a clinician who equals or exceeds the diagnostic accuracy of human experts only after creating and integrating gigantic, common sense knowledge bases with detailed images and contextual knowledge—specific modules for OMR. The limited number of world experts will become a large panel creating the rules, measurements, and other information needed to create these modules. How soon this will happen depends on how much money is available to create these enormous encyclopedias. I guess I will have a job for a few more years.

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