Chapter 29
Relevance of Machine Learning to Cardiovascular Imaging

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ABSTRACT

Artificial intelligence (AI) broadly concerns analytical algorithms that iteratively learn from big datasets, allowing computers to find concealed insights. These encompass a range of operations comprising several terms, including machine learning(ML), cognitive learning, deep learning, and reinforcement learning-based methods that can be used to incorporate and comprehend complex biomedical and healthcare data in scenarios where traditional statistical approaches cannot be implemented. For cardiovascular imaging in particular, machine learning guarantees to be a transformative tool that can address many unmet needs for patient-specific management, accurate prediction of disease progression, and the tracking of identifiable biomarkers of disease processes. In this chapter, the authors discuss fundamentals of machine learning algorithms for image analysis in the cardiovascular system by evaluating the need for ML in this field and examining the potential obstacles and challenges of implementation in the context of three common imaging modalities used in cardiovascular medicine.

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INTRODUCTION

The increase in the number of patients with limited clinical and financial resources and the impact of time-consuming manual diagnostic modalities are serious bottlenecks in treatment capacities for healthcare delivery systems. However, recent developments and availability of high-accuracy and high-throughput clinical grade Artificial Intelligence (AI) tools could be part of the sustainable solutions to tackle this crisis in clinical care. Cardiovascular disease remains a leading cause of mortality, despite up to a quarter of deaths being preventable. Accurate diagnosis will support more effective information sharing. Furthermore, it is becoming incumbent for clinicians to provide personalised advice about interventions and disease progression, using improved methods of information sharing and data analytics (Deborah, 2017). The current model of image acquisition, interpretation, and decision-making presents problems with timing, efficiency, missed diagnoses, and false positive diagnoses. The advancement of cardiovascular imaging has come at a significant financial cost, and by facilitating image acquisition, measurement, reporting, and subsequent clinical pathways, artificial intelligence (AI) may reduce cost and improve value. The dynamic characteristics of the cardiovascular system are essential for understanding both its normal physiology and mechanisms of disease. Therefore, the application of ML to cardiovascular imaging lies at the interface of motion analysis, fluid dynamics, electrophysiology, and molecular cardiology.

In practical terms, AI can be interpreted as the ability of a machine, or a device, to make independent decisions based on the data inputted (Russell, 2003). Machine learning (ML) is a technique used to learn rules and identify patterns progressively from large datasets, without being explicitly programmed or without any a priori assumptions. ML takes many forms, but the most relevant to cardiovascular imaging are supervised and unsupervised learning. Supervised learning involves obtaining prior knowledge that is used to train the model, which often consists of human image annotation or objective categorisation. In contrast, unsupervised learning often involves searching for natural clusters in the data that may identify similar groups. Artificial neural networks (ANN) consists of large number of neurons, each having multiple inputs combined into a single output. Deep learning (DL) is a supervised learning method that mimics human cognition in which more internal layers are used than in traditional neural network approaches.

Most published studies have focused on automated segmentation, post-processing and computer-aided diagnosis. This chapter predominantly focuses on research works on machine learning for three modalities that have potential to be useful in the near future on cardiovascular imaging. We aim to provide a non-systematic narrative overview of the early applications and studies of the implementation of ML in cardiac imaging, categorised by the different imaging modalities: echocardiography, computerised-tomography (CT), magnetic resonance imaging (MRI) and nuclear imaging.

EVOLUTION OF MACHINE LEARNING IN CLINICAL IMAGING

Because of the large number of cardiac images that are routinely acquired with a wide range of modalities (Levin, 2019), there has been a surge in research applying deep learning in the cardiac domain (Figure 1). In this chapter, the authors aim to present an introduction to the basic concepts of deep learning and their possibilities, and offer a review of the state-of-the-art of machine learning reported in works on cardiovascular image analysis.

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