Deep Learning Models in Medical Image Analysis

Prof. Radhika Shetty D S

Computer Science and Engineering
Vivekananda College of Engineering and Technology, Puttur, India

Abstract: Deep learning is a state-of-the-art technology that has rapidly become the method of choice for medical image analysis. The health care sector a high priority sector and consumers expect the highest level of care and services regardless of cost[1]. Medical data mainly include electronic health record data, medical image data, gene information data, etc. This review introduces the application of deep learning in the field of big data analysis and early diagnosis of diseases. Following the success of deep learning in other real-world applications, it is seen as also providing exciting and accurate solutions for medical imaging, and is seen as a key method for future applications in the health care sector.

Introduction

Computer-aided diagnostics (CAD) using artificial intelligence (AI) provides a promising way to make the diagnosis process more efficient and available to the masses. Deep learning is the leading artificial intelligence (AI) method for a wide range of tasks including medical imaging problems[1]. The deep learning method simulates the human neural network. By combining multiple nonlinear processing layers, the original data is abstracted layer by layer, and different levels of abstract features are obtained from the data and used for target detection, classification or segmentation.

Medical care is about the health of people. At present, the amount of medical data is huge, but it is crucial to make good use of this huge medical data to contribute to the medical industry. Although the amount of medical data is huge, there are still many problems: medical data is diverse, including maps, texts, videos, magnets, etc.; due to different equipment used, the quality of data varies greatly; data presents fluctuating characteristics, over time and specific events change; due to differences in individuals, the law of the disease has no universal applicability (4). There are many factors that cannot be dealt with in the existence of these problems. Medical imaging is a very important part of medical data.

This paper describes the studies related to the explainability of deep learning models in the context of medical imaging.

Deep Learning Models

Deep learning has developed into a hot research field, and there are dozens of algorithms, each with its own advantages and disadvantages. These algorithms cover almost all aspects of our image processing, which mainly focus on classification, segmentation.

Machine learning methods are generally divided into *supervised* and *unsupervised learning* algorithms, although there are many nuances[3]. Supervised learning, also known as supervised machine learning, is a subcategory of machine learning and artificial intelligence. It is defined by its use of labeled datasets to train algorithms that to classify data or predict outcomes accurately. As input data is fed into the model, it adjusts its weights until the model has been fitted appropriately, which occurs as part of the cross validation process.

Unsupervised machine learning and supervised machine learning are frequently discussed together. Unlike supervised learning, unsupervised learning uses unlabeled data. From that data, it discovers patterns that help solve for clustering or association problems. This is particularly useful when subject matter experts are unsure of common properties within a data set. Common clustering algorithms are hierarchical, k-means, and Gaussian mixture models.

Neural networks are well known for their good performance in classification and function approximation, and have been used with success in medical image processing over the past years, particularly in the case of preprocessing (e.g. construction and restoration), segmentation, registration and recognition. Image preprocessing with neural networks generally falls into one of the following two categories: image reconstruction and image restoration (Including de-noise and enhancement). The majority of applications of neural networks in medical image preprocessing are found in medical image restoration.

Feed forward neural network[2] is the most used neural network for medical image segmentation. Compared with the traditional Maximum Likelihood Classifier (MLC) based image segmentation method, it has been observed that the feed forward neural networks-based segmented images appear less noisy, and the feed forward neural networks classifier is also less sensitive to the selection of the training sets than the MLC. Hopfield neural network is another most used neural network for medical image segmentation. Hopfield neural networks used here were introduced as a tool for finding satisfactory solutions to complex optimization problems. This makes them an interesting alternative to traditional optimization algorithms for medical image reconstruction which can be formulated as optimization problems.

Detection and recognition of organs and tumors in medical images are prerequisite in medical applications. It is also the final step in the medical image processing, where the goal is to interpret the image content. Using a neural network approach makes it possible to roll several of the preceding stages (preprocessing, segmentation) into one and train it as a single system.

Image or exam classification was one of the first areas in which deep learning made a major contribution to medical image analysis. In exam classification one typically has one or multiple images (an exam) as input with a single diagnostic variable as output (e.g., disease present or not). In such a setting, every diagnostic exam is a sample and dataset sizes are typically small compared to those in computer vision (e.g., hundreds/thousands vs. millions of samples). Image or exam classification was one of the first areas in which deep learning made a major contribution to medical image analysis. In exam classification one typically has one or multiple images (an exam) as input with a single diagnostic variable as output (e.g.,disease present or not). In such a setting, every diagnostic

exam is a sample and dataset sizes are typically small compared to those in computer vision (e.g., hundreds/thousands vs. millions of samples). Image or exam classification was one of the first areas in which deep learning made a major contribution to medical image analysis. In exam classification one typically has one or multiple images (an exam) as in-
put with a single diagnostic variable as output (e.g., disease present or not). In such a setting, every diagnostic exam is a sample and dataset sizes are typically small compared to those in computer vision (e.g., hundreds/thousands vs. millions of samples).
Image or exam classification was one of the first areas in which deep learning made a major contribution to medical image analysis[4]. In exam classification one typically has one or multiple images (an exam) as input with a single diagnostic variable as output (e.g.,disease present or not). In such a setting, every diagnostic exam is a sample and dataset sizes are typically small compared to those in computer vision (e.g., hundreds/thousands vs. millions of samples).

U-Net [5] was proposed by Olaf based on FCN, and has been widely used in medical imaging. Based on the idea of FCN deconvolution to restore image size and feature, U-Net constructs the encoder-decoder structure in the field of semantic segmentation. The encoder gradually reduces the spatial dimension by continuously merging the layers to extract feature information, and the decoder portion gradually restores the target detail and the spatial dimension according to the feature information.

SegNet [5] is a depth semantic segmentation network designed by Cambridge to solve autonomous driving or intelligent robots, which is also based on the encoder-decoder structure. SegNet's encoder and decoder each have 13 convolution layers. The convolutional layer of the encoder corresponds to the first 13 convolutional layers of VGG16. The upsampling part of the decoder uses UnPooling. SegNet records the element position information of the maximum pooling operation when the encoder is downsampled, and restores the image according to the position information when sampling on the decoder.

Finally, deep learning methods have often been described as 'black boxes'[1]. Especially in medicine, where accountability is important and can have serious legal consequences, it is often not enough to have a good prediction system. This system also has to be able to articulate itself in a certain way.

Conclusion

Deep learning is one of the powerful tools for medical image analysis. It has been successfully applied in target detection, segmentation, classification and registration. This paper focuses on the recent developments of deep learning architectures. We can see more and more applications boosted by deep learning capabilities making their way into the market with proactive research and development, enabling users to produce better outcomes quicker and with less experience than before, freeing up expert time to be used in the most challenging cases.

References

1. Singh, Amitojdeep & Sengupta, Sourya & Lakshminarayanan, Vasudevan. (2020). Explainable Deep Learning Models in Medical Image Analysis. Journal of Imaging. 6. 52. 10.3390/jimaging6060052.
2. Shi Z, He L, Suzuki K, Nakamura T, Itoh H. Survey on Neural Networks Used for Medical Image Processing. Int J Comput Sci. 2009 Feb;3(1):86-100. PMID: 26740861; PMCID: PMC4699299.
3. Geert Litjens, Thijs Kooi, Babak Ehteshami Bejnordi, Arnaud Arindra Adiyoso Setio, Francesco Ciompi, Mohsen Ghafoorian, Jeroen A.W.M. van der Laak, Bram van Ginneken, Clara I. Sánchez,A survey on deep learning in medical image analysis,Medical Image Analysis,Volume 42,2017,Pages 60-88,ISSN 1361-8415
4. Litjens, Geert & Kooi, Thijs & Ehteshami Bejnordi, Babak & Setio, Arnaud & Ciompi, Francesco & Ghafoorian, Mohsen & van der Laak, Jeroen & Ginneken, Bram & Sánchez, Clara. (2017). A Survey on Deep Learning in Medical Image Analysis. Medical Image Analysis. 42. 10.1016/j.media.2017.07.005.
5. Cai, L., Gao, J., & Zhao, D. (2020). A review of the application of deep learning in medical image classification and segmentation. *Annals Of Translational Medicine, 8*(11), 713. doi:10.21037/atm.2020.02.44