Chapter 3
An Overview of Biomedical Image Analysis From the Deep Learning Perspective

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ABSTRACT

Biomedical image analysis methods are gradually shifting towards computer-aided solutions from manual investigations to save time and improve the quality of the diagnosis. Deep learning-assisted biomedical image analysis is one of the major and active research areas. Several researchers are working in this domain because deep learning-assisted computer-aided diagnostic solutions are well known for their efficiency. In this chapter, a comprehensive overview of the deep learning-assisted biomedical image analysis methods is presented. This chapter can be helpful for the researchers to understand the recent developments and drawbacks of the present systems. The discussion is made from the perspective of the computer vision, pattern recognition, and artificial intelligence. This chapter can help to get future research directions to exploit the blessings of deep learning techniques for biomedical image analysis.

INTRODUCTION

Biomedical imaging is one of the most important tools which is being used to analyze and diagnose different diseases over a long period of time (Hore et al., 2016). Physicians examines the images to understand the source, type etc. of a disease. Several modalities of the biomedical images are available which are used to diagnose different types of diseases. For example, X-Ray, computed tomography scan (CT-Scan), magnetic resonance imaging (MRI), positron emission tomography (PET), microscopy, ultrasound etc (Alheejawi et al., 2020). In general, biomedical images are studied and interpreted by the

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physicians or radiologists. Due to the huge variations of the diseases, it may be sometimes difficult for the humans to analyze the images appropriately. Moreover, inherent limitations of the humans prevent the experts to explore the hidden patterns from the biomedical images. To reduce the human effort and the inherent errors, manual investigations can be replaced to some extent with the computer assisted diagnosis. The machine learning methods causes a significant advancement in the domain of computer assisted diagnosis and helps in the growth of this field. Machine learning methods coupled with the image processing techniques make the computer assisted diagnosis more powerful and reliable (Greenspan, Van Ginneken, & Summers, 2016).

Artificial intelligence is one of the revolutionary technologies which has a great impact in our everyday life. Machine learning and other advanced computational techniques (Chakraborty & Bhowmik, 2015; Chakraborty & Bhowmik, 2013, 2015; Chakraborty, Seal, & Roy, 2015; Roy, Chakraborty, Mali, Chatterjee, Banerjee, Chakraborty, et al., 2017) based image analysis techniques are very useful to automate the image analysis process. Machine learning methods are used in different stages of image analysis to reduce the human intervention as well as to improve the quality of the results. It is possible to discover various hidden patterns and relationships among the pixels using machine learning techniques (Madabhushi & Lee, 2016). Many times, a human being cannot explore various hidden information from the images which are necessary in various applications of computer vision and image processing like automated object detection (Chakraborty, Chatterjee, Dey, Ashour, & Shi, 2017; Chakraborty, Mali, Chatterjee, Anand, Basu, Banerjee, et al., 2017; Chakraborty, Mali, Chatterjee, Banerjee, Mazumdar, Debnath, et al., 2017), image security (S. Chakraborty, Seal, Roy, & Mali, 2016; Mali, Chakraborty, & Roy, 2015; Mali, Chakraborty, Seal, & Roy, 2015; Roy, Chakraborty, Mali, Banerjee, et al., 2020; Roy, Chakraborty, et al., 2019; Roy, Chakraborty, Mali, Swarnakar, et al., 2020; Roy, Mali, et al., 2019; Seal, Chakraborty, & Mali, 2017) etc.. Machine learning has several applications in various disciplines including manufacturing process, biomedical image analysis, surveillance, space research, bioinformatics, natural language processing and many more. Deep learning is one of the major contributions in artificial intelligence which is frequently used in various disciplines (Lee et al., 2017). Application of the deep learning based artificial intelligence methods in different domains increases the reliability of the automated systems. The efficiency of the deep learning methods makes it suitable to be applied in different domains where high accuracy is required and computational time is restricted. Biomedical image analysis is one of the important domains where the processing time is stipulated and error in the diagnostic outcome can be very costly and dangerous. Deep learning assisted artificial intelligence methods are very useful for this. In recent years, biomedical image analysis becomes a prominent field where deep learning techniques are frequently applied (Chakraborty, Mali, Chatterjee, Banerjee, Roy, Dutta, et al., 2017).

Deep learning allows a neural architecture to learn various complex mathematical models efficiently. It is helpful in accurate data analysis and prediction. The power of deep learning frameworks is well established for different applications. Deep learning frameworks can be efficiently applied for both linear and nonlinear datasets (Lopez, Giro-I-Nieto, Burdick, & Marques, 2017). Several layers are used in the deep learning frameworks which makes the deep learning frameworks powerful enough to efficiently model complex nonlinear functions. Deep learning methods learn a model from a training dataset and that is why deep learning methods belong to supervised category. Deep learning networks are inspired from the Artificial Neural Networks with multiple layers of neurons. After appropriate training, deep learning methods can be effectively applied on some real life scenarios with some unseen data. Deep learning frameworks has a great generalization capabilities which makes it suitable for practical deployment. The application domain of the deep learning frameworks are ever increasing. The root of the deep