Chapter 10

Deep Learning for Tumor Classification:

AI-Driven Diagnostic Decision-Making in Breast Cancer Imaging

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ABSTRACT

This chapter addresses the urgent need for advanced diagnostic methods in breast cancer, which has become the most prevalent cancer among women globally. Radiological techniques such as Positron Emission Tomography - Computed Tomography (PET-CT) and Gamma Camera offer non-invasive, high-resolution imaging crucial for accurate diagnosis and staging. The increasing incidence of breast cancer underscores the demand for faster and more precise diagnostic tools, which Artificial Intelligence (AI) and Machine Learning (ML) can fulfil. This review explores the application of deep learning and neural networks within AI and ML frameworks to enhance the capabilities of radiologists in diagnosing, predicting prognosis, and guiding treatment decisions. Key methodologies including convolutional neural networks and autoencoders are detailed, demonstrating their role in improving the accuracy and efficiency of breast cancer detection and management.

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INTRODUCTION

Breast cancer is emerging to be the highest pervasive cancer globally possesing a staggering increase in incidence rate to 2.3 million cases in 2020, displaying a share of 11.7% in the number of cancer cases worldwide (*Breast Cancer*, n.d.; Mehrotra & Yadav, 2022; Sung et al., 2021). More than half of breast cancer patients in India are diagnosed to have stage 3 and stage 4 cancer, with a woman being diagnosed with the disease in every four minutes and dying in every eight minutes (*Alarming Rise in Breast Cancer Cases in India - The Hindu*, n.d.; *Statistics of Breast Cancer In India | Cytecare Hospitals*, n.d.). The survival rate in India is as low as 60%, 20% lower than the West due to reasons like early onset of about a decade younger than the West (40-50 years of age), late and poor diagnosis, screening, and lack of awareness (*Alarming Rise in Breast Cancer Cases in India - The Hindu*, n.d.; *Statistics of Breast Cancer In India | Cytecare Hospitals*, n.d.).

With such high incidence and mortality rates, the burden of disease diagnostics and treatment increases multifold. Delayed and inadequate diagnosis of cancers like breast cancer and liver cancer have made it imperative to better the existing methods to detect and stage cancer. Primarily, mammography, breast MRI (Magnetic Resonance Imaging), PET (Positron Emission Tomography) with MRI, ultrasound, chest CT (Computed Tomography), CT or without, is applied to stage locally and systemically the extent of breast cancer (Ulaner, 2019). While ultrasonography, MRI, CT, angiography, and PET are commonly applied imaging modalities applied in detection of liver lesions and cancer(Hennedige & Venkatesh, 2012).

The most generally used imaging techniques, for example MRI and CT, are only able to show the structural anatomy of the body. Positron Emission Tomography or PET is capable of imaging physiological and biochemical phenomena. This technique coupled with CT scanning gives a significant gain of not only physiological location of activity but also the structural make up of the site. This assessment of differential physiological phenomena inside the body is done by detecting how certain compounds having nuclear tracers or radiotracers are metabolized(*Positron Emission Tomography - PET Scan | Stanford Health Care*, n.d.; *Positron Emission Tomography and Computed Tomography (PET-CT) Scans | Cancer.Net*, n.d.). The rising prevalence in PET-CT scans can be attributed to its plethora of application in detecting changes in heart and brain physiology, neurological diseases like Alzheimer's, and cancerous growths primary or metastatic(*Positron Emission Tomography - PET Scan | Stanford Health Care*, n.d.).

Another nuclear medicine-based imaging technique, called Scintigraphy, consists of a Gamma Camera, to produce operating scanned images of thyroid, lungs, skeleton, brain, kidneys, gallbladder, and liver (*Gamma Camera Imaging Technique | Medanta*, n.d.). The path of a radioactive tracer is followed inside the organ or tissue of interest by detecting high energy gamma photons of the tracer(*How Does a Gamma Camera Work? -* Www.Medicalradiationinfo.Org, n.d.). These images are used to detect any anomalies in the specific organ or tissue of interest. It forms two dimensional images from the emitted gamma photons from the radiotracer(*Scintigraphy | Definition of Scintigraphy by Medical Dictionary*, n.d.). The gamma camera can identify each of the gamma photons individually (*Gamma Camera: Diagram, Isotopes, Scan & Applications*, n.d.-a).

The surge of large amounts of data being generated, accompanied by the rising need for faster automated diagnosis, prognosis and treatment of cancer cases worldwide, presses upon the use of artificial intelligence and machine learning methods to speed up the process, assist the clinical professionals and eventually give high accuracy results on the detection and prediction of cancers (Figure 1). Artificial intelligence is, according to IBM, a program that powers machines and computers to imitate the decision-making and problem-solving facilities of mind of humans (*What Is Artificial Intelligence (AI) ? | IBM*,

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