Journal of Clinical & Experimental Pathology

Jacob, J Clin Exp Pathol 2023, 13:2

Commentary Open Access

Digital Pathology and Machine Learning for Improved Liver Disease Prognosis

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Received: 30-Jan-2023, Manuscript No. JCEP-23-97228; **Editor assigned:** 03-Feb-2023, PreQC No. JCEP-23-97228 (PQ); **Reviewed:** 17-Feb-2023, QC No. JCEP-23-97228; **Revised:** 24-Feb-2023, Manuscript No. JCEP-23-97228 (R); **Published:** 03-Mar-2023, DOI:10.4172/2161-0681.23.13.436

Citation: Jacob R (2023) Digital Pathology and Machine Learning for Improved Liver Disease Prognosis. J Clin Exp Pathol. 13:436.

Description

While pathologists are still the gold standard in pathology, physically examining physical slides and extracting morphological data for diagnosis in both clinical and non-clinical contexts, interobserver variability limits the ability to compare results across studies and locales. The discipline has been centered on the light microscope, which has remained basically constant even into the current day. With the rapid advancement of several sectors, particularly oncology, pathology modernization is urgently required to keep up with the increasing needs for more robust methods of reading, diagnosing, and stratifying patients in a more objective and simplified manner. To that end, new technologies developed over the last two decades have resulted in the creation of digital pathology, opening the way for AI-based slide reading and analysis.

Whole Slide Imaging (WSI) is one of these technologies. It is a unique technology that enables for the scanning of microscope slides using a specialized whole slide scanner to obtain high-resolution images and digitize histology slides. Once taught with data, AI can evaluate digitized microscope slide images and provide diagnoses when combined with Machine Learning (ML) and other types of neural networks. This is referred to as picture analysis or morphometric analysis. ML is a branch of AI that recognizes and learns from a given dataset using algorithms and extrapolates to new datasets for more accurate learning. Various types of neural networks are important algorithms for ML. Neural networks are algorithms designed to emulate and simulate the cognitive processes of the human brain.

Neural networks work by receiving various types of data as input and processing it through many hidden layers described by an algorithm, which alters the data and eventually returns an output. Different neural network subtypes, such as Deep Neural Networks (DNNs), Convolutional Neural Networks (CNNs), and Artificial Neural Networks (ANNs), each have their own set of applications. WSI, a unique technology that enables for the scanning and digitization of microscope slides using a specialized high-resolution whole slide scanner, is a crucial component of digital pathology. Several companies are making increases in resolution, scanning speed/throughput, and automation to reduce human engagement with scanners. This results in much greater image resolution and significantly reduced pixel size. Furthermore, several manufacturers are creating internal quality control algorithms to ensure WSI quality.

WSI enables the high-throughput automation of formerly time-consuming activities. ML is a broad word that encompasses a wide range of techniques and methodologies. However, the main idea of ML is that computers can learn and improve algorithms with minimum human participation and training data. There are two types of AI training methodologies: supervised learning and unsupervised learning. Supervised learning occurs when a machine learns from labeled data from a training dataset that has a feature that is the AI's aim. For example, histology photos may be submitted to the AI, with certain slides tagged with specific slide features such as cancer cells, stroma, blood arteries, and so on, while others are normal matched tissue slides. Image analysis of digitized slides has been aided using DL neural networks. Warren McCulloch and Walter Pitts presented them in 1943 as a means for an AI to emulate the operations and capabilities of the human brain. In a variety of clinical and non-clinical settings, neural networks have been employed to do activities that need some amount of cognitive ability. Neural networks use "neurons," which are separate mathematical functions that take inputs supplied to them from previous neurons, process them, and then deliver the output to other neurons in different layers of the neural network. WSI and machine learning technologies have seen successful applications in histological examination of hepatic tissue to aid in the diagnosis and treatment of disorders such as Non-Alcoholic Fatty Liver Disease (NAFLD), hepatocellular carcinoma. There has also been discussion on how AI can help in liver transplants.

The current gold standard for diagnosing and grading cannot predict illness progression or survival outcomes. Another prospective use of AI in lung oncology is to investigate the link between pathological characteristics, patient prognosis, and survival outcomes. In previous studies the reserachers utilzed Machine Learning (ML) to assess Non-Small Cell Lung Cancer (NSCLC) tumour samples in order to identify significant features and link them to survival outcomes. They developed completely automated ML models based on 2186 The Cancer Genome Atlas Program WSIs of Lung Adenocarcinoma (LUAD) and Lung Squamous Cell Carcinoma (LUSC) and successfully discriminated short- and long-term survivors of Stage I LUAD and LUSC. In the diagnosis, classification, and prognosis of numerous diseases, digital pathology combined with ML has showed significant improvements over traditional labor-intensive, low-throughput, qualitative, and descriptive manual slide reading by pathologists. The introduction of WSI technology has created potential to create centralized image archives and interact across institutions all over the world. Meanwhile, technology has introduced new hurdles in terms of how to handle enormous amounts of digital image data and extract relevant information from it.

Deep ML-based AI has the ability to process enormous datasets, uncover features and patterns that the human eye cannot see, and make more informed decisions about illness treatment and patient management. As technology advance and regulatory channels become clearer, it is envisaged that AI will be widely used in pathology evaluation in clinical and non-clinical contexts within the next decade.