

Research Question:

How accurately can a machine learning model classify HER2 staining of tumour in breast cancer pathology slides per the Immunohistochemistry (IHC) scoring guidelines?

Outline:

1. Introduction

1.1 Motivation

An Immunohistochemistry (IHC) test is done to determine the gene expression of the human epidermal growth factor receptor 2 (HER2) protein responsible for the growth of healthy breast cells. If this gene is over expressed in patients diagnosed with breast cancer, it will lead to rapid spread of the tumor. However, tumors that are HER2-positive can be treated with chemotherapy if identified early. Pathologists find it very time-consuming to perform the IHC tests manually and the results are often subjective. The motivation of this dissertation is to develop machine learning models that can identify features in the sample pathology slides and classify the specimens in accordance with the IHC scoring guidelines with high accuracy.

1.2. Research Questions

Some of the research questions that would be worth asking when exploring this are,

- How reliably can machine learning models perform IHC scoring compared to human pathologists?
- What features are most informative for HER2 staining classification?

1.3 Overview of the dissertation

The subsequent chapters in this dissertation will cover;

- Chapter 2 – the existing literature on HER2 scoring methods and its automation with machine learning.
- Chapter 3 – the dataset and preprocessing steps.
- Chapter 4 – the proposed machine learning architecture.
- Chapter 5 – discusses the experimental results and model evaluation.
- Chapter 6 – concludes with the implications, shortcomings and future directions.

2. Literature Review

2.1 HER2 Scoring Methods in Breast Cancer Pathology

The most prevalent method is manual pathology where pathologists visually assess staining intensity and extent. The problem is that it is subjective and variable among different observers. It is also time consuming and often a bottleneck when trying to decide to go for relevant chemotherapy before surgery or not. To solve this problem there has been research exploring digital pathology, specifically for IHC scoring of the HER2 protein. This is discussed in section 2.3.

2.2 Machine Learning Applications in HER2 Scoring

There are many existing neural network architectures whose pre-trained models can be fine-tuned for classification of staining intensity and thereby for IHC scoring. Feature extraction work such as texture, shape and staining intensity from the pathology slide images are worth exploring to improve the machine learning models and our own efficiency in identifying these markers.

2.3 State of the Art

The current landscape when it comes to IHC scoring of HER2 protein for breast cancer pathology has explored the integration of digital pathology with machine learning instead of traditional rule-based systems. The following is an overview of the current state-of-the-art research in this area.

2.3.1 Transfer Learning

The work of (Tewary and Mukhopadhyay, 2021) shows deep learning techniques being leveraged for the purpose of IHC scoring of the HER2 stained pathology slides. Another paper that discusses the possibilities of existing ML models is (Che *et al.*, 2023).

2.4 Chapter summary

From the above sections of the literature review, we can see that there is a clear need for digital pathology in this space. Given how existing deep learning vision models have been extensively trained, it makes sense to use transfer learning for this project as evidenced by the already well performing models referred to in the state-of-the-art section (2.3). Building on these insights, the next chapter will delve into the methodology employed in this research. It will outline the dataset selection, preprocessing steps, and the development of a machine learning architecture tailored to enhance the accuracy and reliability of HER2 scoring in breast cancer pathology slides.

References:

Che, Y. *et al.* (2023) 'Immunohistochemical HER2 Recognition and Analysis of Breast Cancer Based on Deep Learning', *Diagnostics*, 13(2). Available at:

<https://doi.org/10.3390/diagnostics13020263>.

Tewary, S. and Mukhopadhyay, S. (2021) 'HER2 Molecular Marker Scoring Using Transfer Learning and Decision Level Fusion', *Journal of Digital Imaging*, 34(3), pp. 667–677. Available at: <https://doi.org/10.1007/s10278-021-00442-5>.