

## **Abstract**

Breast cancer is a major contributor to cancer related mortality among women worldwide, underscoring the importance of early detection and effective management to improve treatment outcomes and survival rates. Although modern computational methods and AI technologies have significantly advanced the field, there remains a pressing need for accessible, reliable, and complementary tools to support effective breast cancer management. This thesis introduces a comprehensive, AI-based multi-modal framework aimed at advancing the classification, prognostication, and personalized treatment planning of breast cancer patients. It is known that mammography is the gold standard for early diagnosis, while histopathological examination is vital for accurate tumor staging. Routine clinical breast examinations, though widely used for initial screening, often lack sensitivity and require domain expertise. A real-time intelligent optical imaging system was developed that uses the principle of transillumination to identify tissue abnormalities in resource-limited settings. To improve diagnostic accuracy, computational models were developed to analyze mammographic images and classify lesions as benign or malignant, reducing subjectivity and increasing reproducibility. Since the rate of recurrence of breast tumors is alarmingly high, the study integrates histopathological imaging data (Whole Slide Images) with genomic data (RNA Seq) to identify predictive biomarkers. Recognizing the growing need for personalized medicine and to understand drug-disease correlations, the research further explores treatment response by identifying differentially expressed genes and regulatory modifiers, supporting personalized therapies. Overall, this work offers a comprehensive and scalable approach that integrates artificial intelligence, imaging and computational biology methods to address critical gaps and advance breast cancer management in diverse healthcare environments.