

# Mammographic Diagnosis for Breast Cancer Biopsy Predictions Using Neural Network Classification Model and Receiver Operating Characteristic (ROC) Curve Evaluation

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**Abstract**—The most common method for screening and diagnosing breast cancer is mammography. However, it lacks high diagnostic accuracy. The low positive predictive values of breast biopsy outcomes using mammogram interpretations often lead to unnecessary biopsies for patients with benign outcomes. In this research report, a mammographic diagnostic method is presented in distinguishing malignant breast cancer and benign disease for biopsy outcome predictions using a neural network classification model and receiver operating characteristic (ROC) curve evaluation. The proposed model uses a two-stage back-propagation neural network approach including both linear and nonlinear components of calculations with iterative training processes and an adjustable learning rate. The iterative training processes along with the adjustable learning rate can ensure that the model has a low minimum mean-square error (MMSE) throughout the training of the model. The probability of misclassification error and performance of our model in diagnosing malignant breast cancer and benign disease for breast biopsy outcome predictions have been evaluated based on a large mammographic mass dataset using the model sensitivity, specificity, and ROC curve analysis. An estimated area of the ROC curve of our model is  $0.9626 \pm 0.0069$  for breast biopsy outcome predictions, which outperforms the diagnostic accuracy of previously reported methods. The sensitivity, specificity, precision, and accuracy of our model simulations are 89.33%, 89.93%, 89.33% and 89.64%, respectively. Therefore, our model along with mammography can provide highly accurate and consistent diagnoses in distinguishing malignant and benign cases for breast cancer biopsy outcome predictions, reducing the number of unnecessary biopsies for patients with benign outcomes.

**Index Terms**—breast cancer, mammography, malignant, benign, biopsy, receiver operating characteristic (ROC) curve, neural network, classification, sensitivity, specificity, precision, minimum mean-square error (MMSE), prediction

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## I. INTRODUCTION

ACCORDING to the World Health Organization [1], 7.6 million people worldwide die from cancer each year. Breast cancer is currently one of the top cancers diagnosed in women in both developed and developing nations. Globally, breast cancer is the principal cause of cancer death among women. Breast cancer tumors typically do not produce symptoms until they are relatively large at advanced stages. Early breast cancer diagnosis improves chances of long-term survival for patients. However, the majority of breast cancer deaths occur in low- and middle-income countries, where most of the women are diagnosed in later stages mainly due to lack of awareness and barriers to health service access [1].

According to Centers for Disease Control and Prevention [2], cancer is the second leading cause of death in the United States. American Cancer Society (ACS) projects an estimated 1,638,910 new cancer cases to occur in 2012 [3-4]. Among all cancer cases, breast cancer ranks as the second leading cause of cancer death and the leading cause of new cancer cases in women [4]. ACS also forecasts 229,060 new cases of invasive breast cancer and 39,920 breast cancer deaths in the United States in 2012.

Female breast cancer mortality rates in the United States initially increased from 1975 to 1990, and then gradually decreased annually up to the current year [5]. The recent decrease in female breast cancer mortality rates is generally attributed to greater awareness of breast cancer, earlier detections, enhanced diagnostic methods, and advanced medical treatments. Thus, diagnosing breast cancer in patients at an early stage before symptoms develop is an important factor influencing their chances of long-term survival.

Cancer is a disease that causes cells in the body to change and grow out of control. Most types of cancer eventually form lumps or masses referred to as tumors [4]. Breast cancer tumors typically do not produce symptoms until they are relatively large at advanced stages [3-4]. Most breast cancer tumors at earlier stages are benign, which are not yet malignant and life-threatening. They do not yet grow uncontrollably or spread. Thus, early detection of breast cancer masses can improve the chances of long-term survival