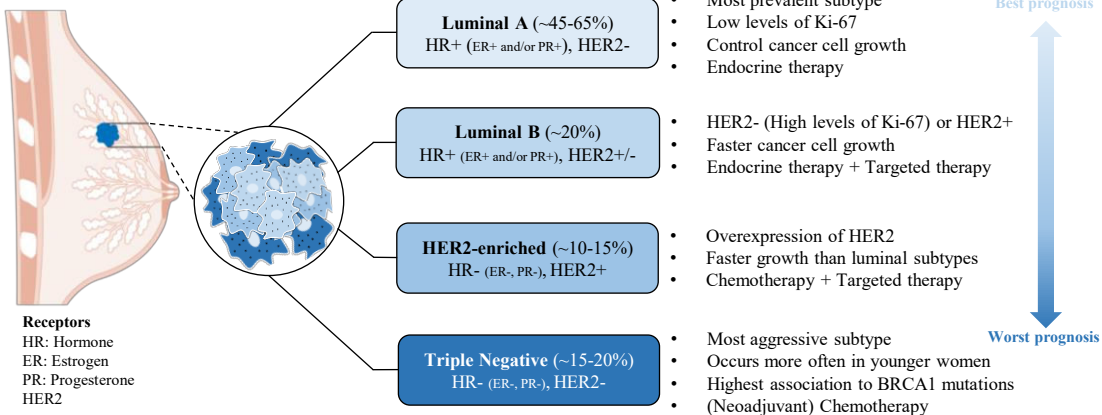# Predicting molecular subtypes of breast cancer using multimodal deep learning and incorporation of the attention mechanism

Introduction
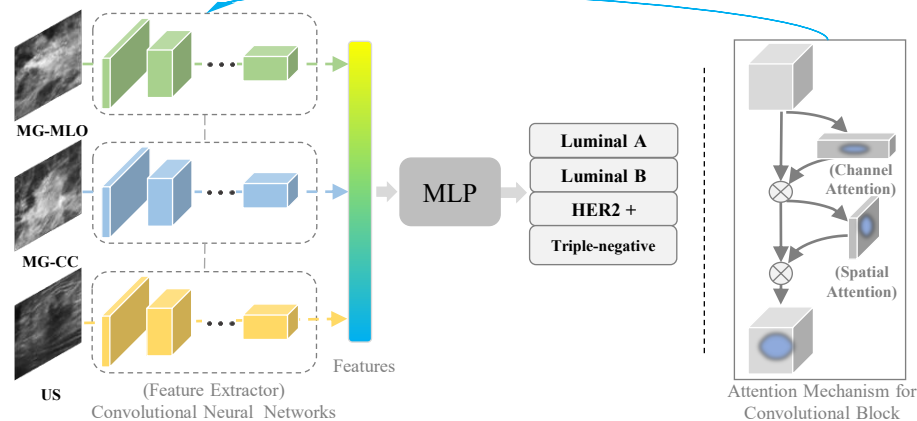
- Breast cancer can be divided into four molecular subtypes, which is usually based upon the expression levels of ER, PR, HER2 and Ki-67.

Luminal A (~45-65%)
HR+ (ER+ and/or PR+), HER2-
- Most prevalent subtype
- Low levels of Ki-67
- Control cancer cell growth
- Endocrine therapy

Luminal B (~20%)
HR+ (ER+ and/or PR+), HER2+/-
- HER2- (High levels of Ki-67) or HER2+
- Faster cancer cell growth
- Endocrine therapy + Targeted therapy

HER2-enriched (~10-15%)
HR- (ER-, PR-), HER2+
- Overexpression of HER2
- Faster growth than luminal subtypes
- Chemotherapy + Targeted therapy

Triple Negative (~15-20%)
HR- (ER-, PR-), HER2-
- Most aggressive subtype
- Occurs more often in younger women
- Highest association to BRCA1 mutations
- (Neoadjuvant) Chemotherapy

Best prognosis → Worst prognosis

Receptors
HR: Hormone
ER: Estrogen
PR: Progesterone
HER2

- ✓ The molecular subtypes of breast cancer is an important factor for the prognosis of breast cancer patients, and can guide treatment selection.

Model

- The overall pipeline diagram of multimodal deep learning with attention mechanism (**MDLA**) model. The model was developed based on residual neural network.

MG-MLO
MG-CC
US
(Feature Extractor) Convolutional Neural Networks
Features
MLP
Luminal A
Luminal B
HER2 +
Triple-negative
(Channel Attention)
(Spatial Attention)
Attention Mechanism for Convolutional Block

- ✓ Two views of mammography (MG, medio-lateral oblique -MLO- and cranio-caudal -CC-) and an ultrasound (US) image of each case (lesion location) were used as input.

Results

- The confusion matrix (for 4-class molecular subtypes) and ROC curve (for Luminal vs Non-Luminal) for predicting molecular subtypes.

ROC curve (area = 0.855)
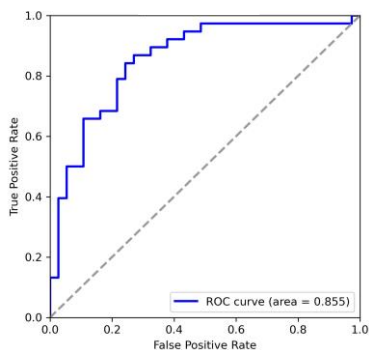
- ✓ The MCC was 0.794 for predicting 4-class molecular subtypes of breast cancer, and the AUC was 0.855 for distinguishing between Luminal and Non-Luminal using MDLA model.

Visualization

- The visualization of MDLA model in predicting 4-class molecular subtypes of breast cancer, including MG and corresponding US.

Original Imaging → Lesion location

MG-MLO   MG-CC   US
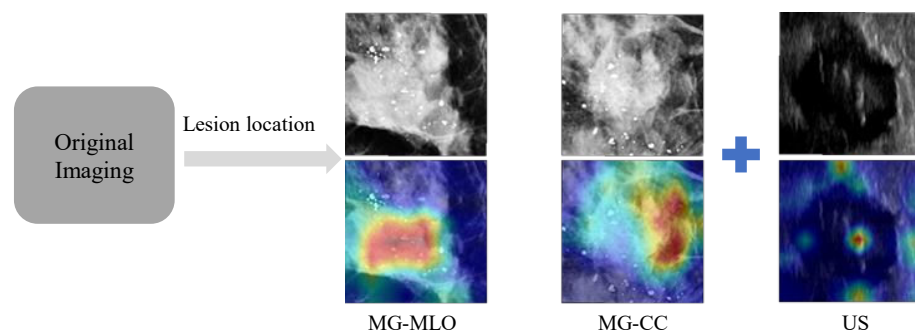
- ✓ The MDLA model focuses on the information of the lesion area of MG and US images, including masses, calcifications, lesion morphology and so on.

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