

Breast cancer classification

Mammogram

Supervised by Dr. Ahmed Said El trass*Models Results*

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| Models | Training and validation accuracy | Training and validation loss | Roc curve | Confusion matrix |
| **Densenet201** |  |  |  |  |
| **Inception\_v3** |  |  |  |  |
| **VGG16** |  |  |  |  |
| **Resnet50** |  |  |  |  |
| **VGG19** |  |  |  | 0 |

*Table1 comparison between pretrained models in (train and validation curves, Roc curve, Confusion M*

*Models Accuracies*

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| *Model* | *accuracy* | *Classification report* |
| ***Densenet201*** | ***0.85*** | **precision recall f1-score support**  **0 0.90 0.79 0.84 100**  **1 0.81 0.91 0.86 100**  **accuracy 0.85 200**  **macro avg 0.86 0.85 0.85 200**  **weighted avg 0.86 0.85 0.85 200** |
| ***VGG19*** | ***0.84*** | **precision recall f1-score support**  **0 0.92 0.76 0.83 100**  **1 0.79 0.93 0.86 100**  **accuracy 0.84 200**  **macro avg 0.86 0.84 0.84 200**  **weighted avg 0.86 0.84 0.84 200** |
| ***Resnet50*** | ***0.83*** | **precision recall f1-score support**  **0 0.90 0.74 0.81 100**  **1 0.78 0.92 0.84 100**  **accuracy 0.83 200**  **macro avg 0.84 0.83 0.83 200**  **weighted avg 0.84 0.83 0.83 200** |
| ***VGG16*** | ***0.82*** | **precision recall f1-score support**  **0 0.85 0.78 0.81 100**  **1 0.80 0.86 0.83 100**  **accuracy 0.82 200**  **macro avg 0.82 0.82 0.82 200**  **weighted avg 0.82 0.82 0.82 200** |
| ***Inception\_V3*** | ***0.79*** | **precision recall f1-score support**  **0 0.82 0.75 0.78 100**  **1 0.77 0.83 0.80 100**  **accuracy 0.79 200**  **macro avg 0.79 0.79 0.79 200**  **weighted avg 0.79 0.79 0.79 200** |

*Table2 comparison between pretrained model’s accuracies and classification report*

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| *model* | *size* | *parameters* | *Top-1 accuracy* | *Top-5 accuracy* |
| ***VGG 16*** | ***528MB*** | ***138,357,544*** | ***0.713*** | ***0.901*** |
| ***VGG19*** | ***549MB*** | ***143,667,240*** | ***0.713*** | ***0.900*** |
| ***Resnet50*** | ***99MB*** | ***25,636,712*** | ***0.749*** | ***0.921*** |
| ***Inception\_V3*** | ***92MB*** | ***23,851,784*** | ***0.779*** | ***0.937*** |
| ***Densenet201*** | ***80MB*** | ***20,242,984*** | ***0.773*** | ***0.936*** |

*Table3.Model’s trained on imagenet dataset*

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| *model* | *Time per image*  *(cpu)* | *Parameters* | *size* |
| ***Resnet50*** | ***0.258*** | ***23,801,218*** | **99MB** |
| ***Inception\_v3*** | ***0.3392*** | ***22,034,978*** | ***92MB*** |
| ***Densenet201*** | ***0.480*** | **18,342,914** | **80MB** |
| ***VGG16*** | ***0.650*** | **14,847,554** | **528MB** |
| ***VGG19*** | ***0.857*** | **20,289,090** | ***549MB*** |

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| *Resnet50* |

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| *fold* | *specifications* | *Confusion matrix* | *Classification report* |
| **1** | **Accuracy: 81%**  ***Loss: 0.4405***  ***Sensitivity:* 86%**  ***Specificity:* 79%**  ***Precision:* 80.37383177%** | **[[79 21]**  **[14 86]]** | **precision recall f1-score support**  **0 0.85 0.79 0.82 100**  **1 0.80 0.86 0.83 100**  **accuracy 0.82 200**  **macro avg 0.83 0.82 0.82 200**  **weighted avg 0.83 0.82 0.82 200** |
| **2** | **Accuracy:81.5%**  ***Loss: 0.*433**  ***Sensitivity:* 88%**  ***Specificity:* 72%**  ***Precision:* 75.86206896551%** | **[[72 28]**  **[12 88]]** | **precision recall f1-score support**  **0 0.86 0.72 0.78 100**  **1 0.76 0.88 0.81 100**  **accuracy 0.80 200**  **macro avg 0.81 0.80 0.80 200**  **weighted avg 0.81 0.80 0.80 200** |
| **3** | **Accuracy: 80.%**  ***Loss: 0.*485**  ***Sensitivity:* 86%**  ***Specificity:* 77%**  ***Precision:* 78.8990825688%** | **[[77 23]**  **[14 86]]** | **precision recall f1-score support**  **0 0.85 0.77 0.81 100**  **1 0.79 0.86 0.82 100**  **accuracy 0.81 200**  **macro avg 0.82 0.81 0.81 200**  **weighted avg 0.82 0.81 0.81 200** |
| **4** | **Accuracy: 79%**  ***Loss: 0.*455**  ***Sensitivity:* 88%**  ***Specificity:* 79%**  ***Precision:* 80.73394495412%** | **[[79 21]**  **[12 88]]** | **precision recall f1-score support**  **0 0.87 0.79 0.83 100**  **1 0.81 0.88 0.84 100**  **accuracy 0.83 200**  **macro avg 0.84 0.83 0.83 200**  **weighted avg 0.84 0.83 0.83 200** |
| **5** | **Accuracy: 79%**  ***Loss: 0.*434**  ***Sensitivity:* 97%**  ***Specificity:* 64%**  ***Precision:* 72.93233082706%** | **[[64 36]**  **[ 3 97]]** | **precision recall f1-score support**  **0 0.96 0.64 0.77 100**  **1 0.73 0.97 0.83 100**  **accuracy 0.81 200**  **macro avg 0.84 0.80 0.80 200**  **weighted avg 0.84 0.81 0.80 200** |
| ***Cv*** | ***1.27*** |  |  |
| **Over all performance**  **(mean& std)** | **Accuracy: 80.2 (+-1.02)%**  **Loss: 0.414 (+- 1.8712)**  **Sensitivity: 89 (+- 4.09)%**  **Specificity: 74 (+- 5.7)%**  **Precision: 77.76 (+- 2.9)%** |  |  |

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| *Inception\_V3* |

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| *fold* | *specifications* | *Confusion matrix* | *Classification report* |
| ***1*** | **Accuracy: 85%**  ***Loss: 0.*384**  **Sensitivity: 84%**  **Specificity: 82%**  **Precision: 82.3529%** | **[[82 18]**  **[16 84]]** | **precision recall f1-score support**  **0 0.84 0.82 0.83 100**  **1 0.82 0.84 0.83 100**  **accuracy 0.83 200**  **macro avg 0.83 0.83 0.83 200**  **weighted avg 0.83 0.83 0.83 200** |
| ***2*** | **Accuracy: 85%**  ***Loss: 0.*354**  **Sensitivity: 88%**  **Specificity: 77%**  **Precision: 79.279%** | **[[77 23]**  **[12 88]]** | **precision recall f1-score support**  **0 0.87 0.77 0.81 100**  **1 0.79 0.88 0.83 100**  **accuracy 0.82 200**  **macro avg 0.83 0.82 0.82 200**  **weighted avg 0.83 0.82 0.82 200** |
| ***3*** | **Accuracy: 85.5%**  ***Loss:0.*325**  **Sensitivity: 94%**  **Specificity: 73%**  **Precision: 77.68595%** | **[[73 27]**  **[ 6 94]]** | **precision recall f1-score support**  **0 0.92 0.73 0.82 100**  **1 0.78 0.94 0.85 100**  **accuracy 0.83 200**  **macro avg 0.85 0.83 0.83 200**  **weighted avg 0.85 0.83 0.83 200** |
| ***4*** | **Accuracy: 84%**  ***Loss:* 0.373**  **Sensitivity: 92%**  **Specificity: 74%**  **Precision: 77.9661%** | **[[74 26]**  **[ 8 92]]** | **precision recall f1-score support**  **0 0.90 0.74 0.81 100**  **1 0.78 0.92 0.84 100**  **accuracy 0.83 200**  **macro avg 0.84 0.83 0.83 200**  **weighted avg 0.84 0.83 0.83 200** |
| ***5*** | **Accuracy: 84%**  ***Loss: 0.356***  **Sensitivity: 94%**  **Specificity: 77%**  **Precision: 80.34188%** | **[[77 23]**  **[ 6 94]]** | **precision recall f1-score support**  **0 0.93 0.77 0.84 100**  **1 0.80 0.94 0.87 100**  **accuracy 0.85 200**  **macro avg 0.87 0.85 0.85 200**  **weighted avg 0.87 0.85 0.85 200** |
| ***Cv*** | ***0.708*** |  |  |
| ***Over all performance***  ***(mean & std)*** | **Accuracy: 84.7 (+- 0.60)%**  **Loss: 0.386 (+- 2.33)**  **Sensitivity:90.39 (+-3.87)%**  **Specificity:76.59 (+-3.136)%**  **Precision:79.5 (+- 1.7)%** |  |  |

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| *Densenet201* |

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| *fold* | *specifications* | *Confusion matrix* | *Classification report* |
| ***1*** | **Accuracy: 89%**  ***Loss: 0.314***  **Sensitivity: 93%**  **Specificity: 83%**  **Precision: 84.5454545%** | **[[83 17]**  **[ 7 93]]** | **precision recall f1-score support**  **0 0.92 0.83 0.87 100**  **1 0.85 0.93 0.89 100**  **accuracy 0.88 200**  **macro avg 0.88 0.88 0.88 200**  **weighted avg 0.88 0.88 0.88 200** |
| ***2*** | **Accuracy: 87.5%**  ***Loss: 0.*298**  **Sensitivity: 98%**  **Specificity: 79%**  **Precision:82.35294117%** | **[[79 21]**  **[ 2 98]]** | **precision recall f1-score support**  **0 0.98 0.79 0.87 100**  **1 0.82 0.98 0.89 100**  **accuracy 0.89 200**  **macro avg 0.90 0.89 0.88 200**  **weighted avg 0.90 0.89 0.88 200** |
| ***3*** | **Accuracy: 86.5%**  ***Loss: 0.*336**  **Sensitivity: 98%**  **Specificity: 79%**  **Precision: 82.35294117%** | **[[79 21]**  **[ 2 98]]** | **precision recall f1-score support**  **0 0.98 0.79 0.87 100**  **1 0.82 0.98 0.89 100**  **accuracy 0.89 200**  **macro avg 0.90 0.89 0.88 200**  **weighted avg 0.90 0.89 0.88 200** |
| ***4*** | **Accuracy: 88%**  ***Loss: 0.*334**  **Sensitivity: 89%**  **Specificity: 80%**  **Precision: 81.651376%** | **[[80 20]**  **[11 89]]** | **precision recall f1-score support**  **0 0.88 0.80 0.84 100**  **1 0.82 0.89 0.85 100**  **accuracy 0.84 200**  **macro avg 0.85 0.84 0.84 200**  **weighted avg 0.85 0.84 0.84 200** |
| ***5*** | **Accuracy: 90.5%**  ***Loss: 0.*264**  **Sensitivity: 93%**  **Specificity: 83%**  **Precision: 84.545454%** | **[[83 17]**  **[ 7 93]]** | **precision recall f1-score support**  **0 0.92 0.83 0.87 100**  **1 0.85 0.93 0.89 100**  **accuracy 0.88 200**  **macro avg 0.88 0.88 0.88 200**  **weighted avg 0.88 0.88 0.88 200** |
| ***Cv*** | ***1.54*** |  |  |
| ***Over all performance***  ***(mean & std)*** | **Accuracy: 88.3(+-1.36) %**  **Loss: 0.29389 (+- 1.459)**  **Sensitivity: 94.2(+- 3.429)%**  **Specificity: 80.8 (+- 1.833)%**  **Precision: 83 (+-1.215)%** |  |  |

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| *VGG16* |

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| *fold* | *specifications* | *Confusion matrix* | *Classification report* |
| ***1*** | **Accuracy: 84%**  ***Loss: 0.*351**  **Sensitivity: 99%**  **Specificity: 74%**  **Precision: 79.2 %** | **[[74 26]**  **[ 1 99]]** | **precision recall f1-score support**  **0 0.99 0.74 0.85 100**  **1 0.79 0.99 0.88 100**  **accuracy 0.86 200**  **macro avg 0.89 0.86 0.86 200**  **weighted avg 0.89 0.86 0.86 200** |
| ***2*** | **Accuracy: 88%**  ***Loss: 0.304***  **Sensitivity: 91%**  **Specificity: 81%**  **Precision: 82.727272 %** | **[[81 19]**  **[ 9 91]]** | **precision recall f1-score support**  **0 0.90 0.81 0.85 100**  **1 0.83 0.91 0.87 100**  **accuracy 0.86 200**  **macro avg 0.86 0.86 0.86 200**  **weighted avg 0.86 0.86 0.86 200** |
| ***3*** | **Accuracy: 84%**  ***Loss: 0.334***  **Sensitivity: 90%**  **Specificity: 73%**  **Precision: 76.923076%** | **[[73 27]**  **[10 90]]** | **precision recall f1-score support**    **0 0.88 0.73 0.80 100**  **1 0.77 0.90 0.83 100**  **accuracy 0.81 200**  **macro avg 0.82 0.81 0.81 200**  **weighted avg 0.82 0.81 0.81 200** |
| ***4*** | **Accuracy: 86%**  ***Loss: 0.333***  **Sensitivity: 100%**  **Specificity: 75%**  **Precision: 80%** | **[[ 75 25]**  **[ 0 100]]** | **precision recall f1-score support**  **0 1.00 0.75 0.86 100**  **1 0.80 1.00 0.89 100**  **accuracy 0.88 200**  **macro avg 0.90 0.88 0.87 200**  **weighted avg 0.90 0.88 0.87 200** |
| ***5*** | **Accuracy: 84%**  ***Loss: 0.324***  **Sensitivity: 94%**  **Specificity: 83%**  **Precision: 84.684684%** | **[[83 17]**  **[ 6 94]]** | **precision recall f1-score support**    **0 0.93 0.83 0.88 100**  **1 0.85 0.94 0.89 100**  **accuracy 0.89 200**  **macro avg 0.89 0.89 0.88 200**  **weighted avg 0.89 0.89 0.88 200** |
| ***Cv*** | ***1.68*** |  |  |
| ***Over all performance***  ***(mean & std)*** | **Accuracy:85.3(+- 1.43) %**  **Loss: 0.33963 (+-2.749)**  **Sensitivity: 94.8 (+4.06)%**  **Specificity:77.2 (+- 4.019)%**  **Precision: 80.7(+- 2.72)%** |  |  |

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| *VGG19* |

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| *fold* | *specifications* | *Confusion matrix* | *Classification report* |
| ***1*** | **Accuracy: 88%**  ***Loss: 0.339***  **Sensitivity: 97%**  **Specificity: 76%**  **Precision: 80.16528925%** | **[[76 24]**  **[ 3 97]]** | **precision recall f1-score support**  **0 0.96 0.76 0.85 100**  **1 0.80 0.97 0.88 100**  **accuracy 0.86 200**  **macro avg 0.88 0.86 0.86 200**  **weighted avg 0.88 0.86 0.86 200** |
| ***2*** | **Accuracy: 81.5%**  ***Loss: 0.40***  **Sensitivity: 96%**  **Specificity: 82%**  **Precision: 84.21052631%** | **[[82 18]**  **[ 4 96]]** | **precision recall f1-score support**  **0 0.95 0.82 0.88 100**  **1 0.84 0.96 0.90 100**  **accuracy 0.89 200**  **macro avg 0.90 0.89 0.89 200**  **weighted avg 0.90 0.89 0.89 200** |
| ***3*** | **Accuracy: 83.5%**  ***Loss: 0.345***  **Sensitivity: 84%**  **Specificity: 89%**  **Precision: 88.42105263%** | **[[89 11]**  **[16 84]]** | **precision recall f1-score support**  **0 0.85 0.89 0.87 100**  **1 0.88 0.84 0.86 100**  **accuracy 0.86 200**  **macro avg 0.87 0.86 0.86 200**  **weighted avg 0.87 0.86 0.86 200** |
| ***4*** | **Accuracy: 87.5%**  ***Loss: 0.326***  **Sensitivity: 97%**  **Specificity: 81%**  **Precision: 83.620689%** | **[[81 19]**  **[ 3 97]]** | **precision recall f1-score support**  **0 0.96 0.81 0.88 100**  **1 0.84 0.97 0.90 100**  **accuracy 0.89 200**  **macro avg 0.90 0.89 0.89 200**  **weighted avg 0.90 0.89 0.89 200** |
| ***5*** | **Accuracy: 87%**  ***Loss: 0.318***  **Sensitivity: 91%**  **Specificity: 82%**  **Precision: 83.48623853%** | **[[82 18]**  **[ 9 91]]** | **precision recall f1-score support**    **0 0.90 0.82 0.86 100**  **1 0.83 0.91 0.87 100**  **accuracy 0.86 200**  **macro avg 0.87 0.86 0.86 200**  **weighted avg 0.87 0.86 0.86 200** |
| ***Cv*** | ***2.97*** |  |  |
| ***Over all performance***  ***(mean & std)*** | **Accuracy: 85.5(+- 2.54) %**  **Loss: 0.311509 (+-1.578)**  **Sensitivity: 93 (+-5.019)%**  **Specificity: 82 (+- 4.147)%**  **Precision: 83.98 (+- 2.63)%** |  |  |