

Breast cancer classification

Mammogram

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Model* | *accuracy* | *sensitivity* | *specificity* | *Classification report* |
| ***Densenet201*** | ***0.85*** | ***0.91*** | ***0.79*** | **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*** | ***0.93*** | ***0.76*** | **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*** | ***0.92*** | ***0.74*** | **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*** | ***0.86*** | ***0.78*** | **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*** | ***0.83*** | ***0.75*** | **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***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *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***

|  |  |  |  |
| --- | --- | --- | --- |
| *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* |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *fold* | | *accuracy* | | *loss* | | *sensitivity* | | *specificity* | | *Confusion matrix* | | *Classification report* | | | | | |
| **1** | **81%** | | **0.445** | | **0.94** | | ***0.68*** | | **[[68 32]**  **[ 6 94]]** | | **precision recall f1-score support**  **0 0.92 0.68 0.78 100**  **1 0.75 0.94 0.83 100**    **accuracy 0.81 200**  **macro avg 0.83 0.81 0.81 200**  **weighted avg 0.83 0.81 0.81 200** | | | | | | |
| **2** | **81.5 %** | | **0.433** | | **0.98** | | ***0.65*** | | **[[65 35]**  **[ 2 98]]** | | **precision recall f1-score support**  **0 0.97 0.65 0.78 100**  **1 0.74 0.98 0.84 100**  **accuracy 0.81 200**  **macro avg 0.85 0.81 0.81 200**  **weighted avg 0.85 0.81 0.81 200** | | | | | | |
| **3** | **80.5%** | | **0.485** | | **0.99** | | ***0.62*** | | **[[62 38]**  **[ 1 99]]** | | **precision recall f1-score support**  **0 0.98 0.62 0.76 100**  **1 0.72 0.99 0.84 100**  **accuracy 0.81 200**  **macro avg 0.85 0.80 0.80 200**  **weighted avg 0.85 0.81 0.80 200** | | | | | | |
| **4** | **79%** | | **0.455** | | **0.95** | | ***0.63*** | | **[[63 37]**  **[ 5 95]]** | | **precision recall f1-score support**  **0 0.93 0.63 0.75 100**  **1 0.72 0.95 0.82 100**  **accuracy 0.79 200**  **macro avg 0.82 0.79 0.78 200**  **weighted avg 0.82 0.79 0.78 200** | | | | | | |
| **5** | **79%** | | **0.434** | | **0.89** | | ***0.69*** | | **[[69 31]**  **[11 89]]** | | **precision recall f1-score support**  **0 0.86 0.69 0.77 100**  **1 0.74 0.89 0.81 100**  **accuracy 0.79 200**  **macro avg 0.80 0.79 0.79 200**  **weighted avg 0.80 0.79 0.79 200** | | | | | | |
| **Standard deviation**  **(accuracy)** | | **1.02** | | ***Average loss***  ***(accuracy)*** | | | | | | ***0.451*** | | ***Standard deviation***  ***(sensitivity)*** | ***3.937*** | ***Over all performance***  ***(sensitivity)*** | ***95(+-3.937) %*** | ***Over all performance***  ***(precision)*** | ***73.4 (+-1.41) %*** |
| ***Over all performance***  **(accuracy)** | | **80.2 (+-1.02) %** | | ***Cv***  ***(accuracy)*** | | | | | | ***1.27*** | | ***Standard deviation***  ***(specificity)*** | ***3.08*** | ***Over all performance***  ***(specificity)*** | ***65.4(+-3.08) %*** | ***Over all performance***  ***(f1 score)*** | ***82.8 (+-1.58) %*** |

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| *Inception\_V3* |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *fold* | *accuracy* | *loss* | *sensitivity* | *specificity* | *Confusion matrix* | *Classification report* | | | | | |
| ***1*** | **85%** | **0.384** | **0.90** | ***0.80*** | **[[80 20]**  **[10 90]]** | **precision recall f1-score support**  **0 0.89 0.80 0.84 100**  **1 0.82 0.90 0.86 100**  **accuracy 0.85 200**  **macro avg 0.85 0.85 0.85 200**  **weighted avg 0.85 0.85 0.85 200** | | | | | |
| ***2*** | **85%** | **0.354** | **0.88** | ***0.82*** | **[[82 18]**  **[12 88]]** | **precision recall f1-score support**  **0 0.87 0.82 0.85 100**  **1 0.83 0.88 0.85 100**  **accuracy 0.85 200**  **macro avg 0.85 0.85 0.85 200**  **weighted avg 0.85 0.85 0.85 200** | | | | | |
| ***3*** | **85.5%** | **0.325** | **0.90** | ***0.81*** | **[[81 19]**  **[10 90]]** | **precision recall f1-score support**  **0 0.89 0.81 0.85 100**  **1 0.83 0.90 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** | | | | | |
| ***4*** | **84%** | **0.373** | **0.95** | ***0.73*** | **[[73 27]**  **[ 5 95]]** | **precision recall f1-score support**  **0 0.94 0.73 0.82 100**  **1 0.78 0.95 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** | | | | | |
| ***5*** | **84%** | **0.356** | **0.89** | ***0.79*** | **[[79 21]**  **[11 89]]** | **precision recall f1-score support**  **0 0.88 0.79 0.83 100**  **1 0.81 0.89 0.85 100**  **accuracy 0.84 200**  **macro avg 0.84 0.84 0.84 200**  **weighted avg 0.84 0.84 0.84 200** | | | | | |
| ***Standard deviation***  ***(accuracy)*** | **0.60** | ***Average loss***  ***(accuracy)*** | | | **0.359** | ***Standard deviation***  ***(sensitivity)*** | ***2.73*** | ***Over all performance***  ***(sensitivity)*** | ***90.4(+-2.73) %*** | ***Over all performance***  ***(precision)*** | ***81.4(+-2.12) %*** |
| ***Over all performance***  ***(accuracy)*** | **84.7 (+- 0.60) %** | ***Cv***  ***(accuracy)*** | | | ***0.708*** | ***Standard deviation***  ***(specificity)*** | ***3.53*** | ***Over all performance***  ***(specificity)*** | ***79(+-3.53) %*** | ***Over all performance***  ***(f1score)*** | ***85.6(+-0.86) %*** |

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| *Densenet201* |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *fold* | | *accuracy* | | *loss* | | *sensitivity* | | *specificity* | | *Confusion matrix* | | *Classification report* | | | | | |
| ***1*** | | **89%** | | **0.314** | | **0.95** | | ***0.80*** | | **[[82 18]**  **[ 4 96]]** | | **precision recall f1-score support**  **0 0.94 0.80 0.86 100**  **1 0.83 0.95 0.88 100**  **accuracy 0.88 200**  **macro avg 0.88 0.88 0.87 200**  **weighted avg 0.88 0.88 0.87 200** | | | | | | |
| ***2*** | | **87.5%** | | **0.298** | | **0.95** | | ***0.80*** | | **[[80 20]**  **[ 5 95]]** | | **precision recall f1-score support**  **0 0.94 0.80 0.86 100**  **1 0.83 0.95 0.88 100**  **accuracy 0.88 200**  **macro avg 0.88 0.88 0.87 200**  **weighted avg 0.88 0.88 0.87 200** | | | | | | |
| ***3*** | | **86.5%** | | **0.336** | | **0.96** | | ***0.77*** | | **[[77 23]**  **[ 4 96]]** | | **precision recall f1-score support**  **0 0.95 0.77 0.85 100**  **1 0.81 0.96 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** | | | | | | |
| ***4*** | | **88%** | | **0.334** | | **0.91** | | ***0.85*** | | **[[85 15]**  **[ 9 91]]** | | **precision recall f1-score support**  **0 0.90 0.85 0.88 100**  **1 0.86 0.91 0.88 100**  **accuracy 0.88 200**  **macro avg 0.88 0.88 0.88 200**  **weighted avg 0.88 0.88 0.88 200** | | | | | | |
| ***5*** | | **90.5 %** | | **0.264** | | **0.93** | | ***0.88*** | | **[[88 12]**  **[ 7 93]]** | | **precision recall f1-score support**  **0 0.93 0.88 0.90 100**  **1 0.89 0.93 0.91 100**  **accuracy 0.91 200**  **macro avg 0.91 0.91 0.90 200**  **weighted avg 0.91 0.91 0.90 200** | | | | | | |
| ***Standard deviation***  ***(accuracy)*** | | **1.36** | | ***Average loss***  ***(accuracy)*** | | | | | | ***0.309*** | | ***Standard deviation***  ***(sensitivity)*** | ***2.0*** | ***Over all performance***  ***(sensitivity)*** | ***94(+-2.0) %*** | ***Over all performance***  ***(precision)*** | ***84.4(+-3.16) %*** |
| ***Over all performance***  ***(accuracy)*** | | **88.3(+-1.36) %** | | ***Cv***  ***(accuracy)*** | | | | | | ***1.54*** | | ***Standard deviation***  ***(specificity)*** | ***4.41*** | ***Over all performance***  ***(specificity)*** | ***82(+-4.41) %*** | ***Over all performance***  ***(f1score)*** | ***88.8(+-1.5) %*** |

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| *VGG16* |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *fold* | *accuracy* | *loss* | *senstivity* | | *specificity* | | *Confusion matrix* | *Classification report* | | | | | |
| ***1*** | **84%** | **0.351** | | **0.92** | | ***0.77*** | **[[77 23]**  **[ 8 92]]** | **precision recall f1-score support**  **0 0.91 0.77 0.83 100**  **1 0.80 0.92 0.86 100**  **accuracy 0.84 200**  **macro avg 0.85 0.84 0.84 200**  **weighted avg 0.85 0.84 0.84 200** | | | | | |
| ***2*** | **88%** | **0.304** | | **0.90** | | ***0.85*** | **[[85 15]**  **[10 90]]** | **precision recall f1-score support**  **0 0.89 0.85 0.87 100**  **1 0.86 0.90 0.88 100**  **accuracy 0.88 200**  **macro avg 0.88 0.88 0.87 200**  **weighted avg 0.88 0.88 0.87 200** | | | | | |
| ***3*** | **84%** | **0.334** | | **0.92** | | ***0.76*** | **[[76 24]**  **[ 8 92]]** | **precision recall f1-score support**    **0 0.90 0.76 0.83 100**  **1 0.79 0.92 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** | | | | | |
| ***4*** | **86%** | **0.333** | | **0.92** | | ***0.81*** | **[[81 19]**  **[ 8 92]]** | **precision recall f1-score support**  **0 0.91 0.81 0.86 100**  **1 0.83 0.92 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** | | | | | |
| ***5*** | **84%** | **0.324** | | **0.87** | | ***0.81*** | **[[81 19]**  **[13 87]]** | **precision recall f1-score support**    **0 0.86 0.81 0.84 100**  **1 0.82 0.87 0.84 100**  **accuracy 0.84 200**  **macro avg 0.84 0.84 0.84 200**  **weighted avg 0.84 0.84 0.84 200** | | | | | |
| ***Standard deviation***  ***(accuracy)*** | **1.43** | ***Average loss***  ***(accuracy)*** | | | | | **0.329** | ***Standard deviation***  ***(sensitivity)*** | ***2.29*** | ***Over all performance***  ***(sensitivity)*** | ***90.6(+-2.29) %*** | ***Over all performance***  ***(precision)*** | ***82(+-2.73) %*** |
| ***Over all performance***  ***(accuracy)*** | **85.3(+- 1.43) %** | ***Cv***  ***(accuracy)*** | | | | | ***1.68*** | ***Standard deviation***  ***(specificity)*** | ***3.60*** | ***Over all performance***  ***(specificity)*** | ***80.0(+-3.60) %*** | ***Over all performance***  ***(f1score)*** | ***86(+-1.58) %*** |

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| *VGG19* |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *fold* | *accuracy* | *loss* | *sensitivity* | *specificity* | *Confusion matrix* | *Classification report* | | | | | |
| ***1*** | **88%** | **0.339** | **0.94** | ***0.82*** | **[[82 18]**  **[ 6 94]]** | **precision recall f1-score support**  **0 0.93 0.82 0.87 100**  **1 0.84 0.94 0.89 100**  **accuracy 0.88 200**  **macro avg 0.89 0.88 0.88 200**  **weighted avg 0.89 0.88 0.88 200** | | | | | |
| ***2*** | **81.5%** | **0.400** | **0.89** | ***0.81*** | **[[81 19]**  **[10 82]]** | **precision recall f1-score support**  **0 0.82 0.81 0.81 100**  **1 0.81 0.82 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** | | | | | |
| ***3*** | **83.5%** | **0.345** | **0.89** | ***0.78*** | **[[78 22]**  **[ 11 89]]** | **precision recall f1-score support**  **0 0.88 0.78 0.83 100**  **1 0.80 0.89 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** | | | | | |
| ***4*** | **87.5%** | **0.326** | **0.97** | ***0.78*** | **[[78 22]**  **[ 3 97]]** | **precision recall f1-score support**  **0 0.96 0.78 0.86 100**  **1 0.82 0.97 0.89 100**  **accuracy 0.88 200**  **macro avg 0.89 0.88 0.87 200**  **weighted avg 0.89 0.88 0.87 200** | | | | | |
| ***5*** | **87%** | **0.318** | **0.95** | ***0.79*** | **[[79 21]**  **[5 95]]** | **precision recall f1-score support**    **0 0.94 0.79 0.86 100**  **1 0.82 0.95 0.88 100**  **accuracy 0.87 200**  **macro avg 0.88 0.87 0.87 200**  **weighted avg 0.88 0.87 0.87 200** | | | | | |
| ***Standard deviation***  ***(accuracy)*** | **2.54** | ***Average loss***  ***(accuracy)*** | | | **0.348** | ***Standard deviation***  ***(sensitivity)*** | ***3.74*** | ***Over all performance***  ***(sensitivity)*** | ***92.8(+-3.74) %*** | ***Over all performance***  ***(precision)*** | ***81.8(+-1.73) %*** |
| ***Over all performance***  ***(accuracy)*** | **85.5(+- 2.54) %** | ***Cv***  ***(accuracy)*** | | | ***2.97*** | ***Standard deviation***  ***(specificity)*** | ***1.93*** | ***Over all performance***  ***(specificity)*** | ***79.6(+-1.93) %*** | ***Over all performance***  ***(f1score)*** | ***86.4(+-3.24) %*** |