# Machine Learning Results

**Mean Accuracy**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feature | KNN | Random Forest | XGBoost | Decision Tree | Extra Trees |
| Feature 5 | 0.84 | 0.83 | 0.72 | 0.74 | 0.83 |
| Feature 8 | 0.95 | 0.93 | 0.82 | 0.84 | 0.94 |
| Feature 16 | 0.99 | 0.98 | 0.92 | 0.90 | 0.99 |
| Feature 22 | 1.00 | 0.99 | 0.95 | 0.91 | 0.99 |
| Feature 27 | 1.00 | 0.99 | 0.95 | 0.91 | 0.99 |
| All Features | 1.00 | 0.99 | 0.96 | 0.91 | 0.99 |

**Mean Precision**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feature | KNN | Random Forest | XGBoost | Decision Tree | Extra Trees |
| Feature 5 | 0.86 | 0.84 | 0.75 | 0.74 | 0.86 |
| Feature 8 | 0.96 | 0.95 | 0.84 | 0.84 | 0.96 |
| Feature 16 | 1.00 | 0.99 | 0.97 | 0.90 | 0.99 |
| Feature 22 | 1.00 | 0.99 | 0.96 | 0.91 | 1.00 |
| Feature 27 | 1.00 | 0.99 | 0.97 | 0.91 | 1.00 |
| All Features | 1.00 | 0.99 | 0.97 | 0.91 | 1.00 |

**Mean Recall**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feature | KNN | Random Forest | XGBoost | Decision Tree | Extra Trees |
| Feature 5 | 0.81 | 0.80 | 0.67 | 0.74 | 0.79 |
| Feature 8 | 0.94 | 0.91 | 0.79 | 0.83 | 0.91 |
| Feature 16 | 1.00 | 0.97 | 0.94 | 0.89 | 0.99 |
| Feature 22 | 0.99 | 0.98 | 0.93 | 0.90 | 0.99 |
| Feature 27 | 1.00 | 0.99 | 0.94 | 0.91 | 0.99 |
| All Features | 1.00 | 0.99 | 0.95 | 0.91 | 0.99 |

**Mean F1 Score**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feature | KNN | Random Forest | XGBoost | Decision Tree | Extra Trees |
| Feature 5 | 0.84 | 0.83 | 0.72 | 0.74 | 0.83 |
| Feature 8 | 0.95 | 0.93 | 0.81 | 0.84 | 0.93 |
| Feature 16 | 0.99 | 0.98 | 0.92 | 0.90 | 0.99 |
| Feature 22 | 1.00 | 0.99 | 0.94 | 0.91 | 0.99 |
| Feature 27 | 1.00 | 0.99 | 0.95 | 0.91 | 0.99 |
| All Features | 1.00 | 0.99 | 0.96 | 0.91 | 0.99 |

# Deep Learning Results

**Mean Accuracy**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM | Meta Learning |
| Feature 5 | 0.869 | 0.882 | 0.878 | 0.899 |
| Feature 8 | 0.991 | 0.983 | 0.984 | 0.994 |
| Feature 16 | 0.999 | 0.871 | 0.751 | 0.999 |
| Feature 22 | 0.999 | 0.768 | 0.803 | 0.999 |
| Feature 27 | 0.999 | 0.865 | 0.671 | 0.999 |
| All Features | 0.999 | 0.809 | 0.674 | 0.999 |

**Mean Precision**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM | Meta Learning |
| Feature 5 | 0.873 | 0.888 | 0.894 | 0.904 |
| Feature 8 | 0.994 | 0.984 | 0.987 | 0.994 |
| Feature 16 | 0.999 | 0.905 | 0.777 | 0.999 |
| Feature 22 | 0.999 | 0.779 | 0.845 | 0.999 |
| Feature 27 | 0.999 | 0.871 | 0.687 | 0.999 |
| All Features | 0.999 | 0.809 | 0.681 | 0.999 |

**Mean Recall**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM | Meta Learning |
| Feature 5 | 0.863 | 0.874 | 0.859 | 0.892 |
| Feature 8 | 0.988 | 0.983 | 0.980 | 0.994 |
| Feature 16 | 0.999 | 0.828 | 0.704 | 0.999 |
| Feature 22 | 0.999 | 0.747 | 0.742 | 0.999 |
| Feature 27 | 0.999 | 0.857 | 0.629 | 0.999 |
| All Features | 0.999 | 0.808 | 0.653 | 0.999 |

**Mean F1-Score**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM | Meta Learning |
| Feature 5 | 0.868 | 0.881 | 0.876 | 0.898 |
| Feature 8 | 0.991 | 0.983 | 0.984 | 0.994 |
| Feature 16 | 0.999 | 0.865 | 0.739 | 0.999 |
| Feature 22 | 0.999 | 0.768 | 0.790 | 0.999 |
| Feature 27 | 0.999 | 0.864 | 0.657 | 0.999 |
| All Features | 0.999 | 0.809 | 0.667 | 0.999 |

**Training Time (in seconds)**

|  |  |  |  |
| --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM |
| Feature 5 | 741.125629663 | 54625.3885355 | 4259.20539856 |
| Feature 8 | 741.126 | 50761.767 | 4259.205 |
| Feature 16 | 741.126 | 24284.623 | 22654.002 |
| Feature 22 | 741.126 | 31387.675 | 33376.968 |
| Feature 27 | 741.126 | 40605.695 | 48549.215 |
| All Features | 4079.91 | 43740.789 | 62036.164 |

**Callback Epochs**

|  |  |  |  |
| --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM |
| Feature 5 | 273 | 230 | 216 |
| Feature 8 | 273 | 140 | 216 |
| Feature 16 | 273 | 35 | 34 |
| Feature 22 | 273 | 33 | 37 |
| Feature 27 | 273 | 35 | 44 |
| All Features | 120 | 34 | 52 |

**Training Time per Epoch (in seconds)**

|  |  |  |  |
| --- | --- | --- | --- |
| Feature | ANN | GRU | LSTM |
| Feature 5 | 2.71 | 237.50 | 19.72 |
| Feature 8 | 2.71 | 362.58 | 19.72 |
| Feature 16 | 2.71 | 694.13 | 666.29 |
| Feature 22 | 2.71 | 950.87 | 902.05 |
| Feature 27 | 2.71 | 1,160.16 | 1,103.39 |
| All Features | 33.99 | 1,286.49 | 1,192.04 |

Overall Performance Comparison

**Mean Accuracy**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Feature | XGBoost | Decision Tree | Random Forest | Extra Trees | KNN | ANN | GRU | LSTM | Meta Learning |
| Feature 5 | 0.72 | 0.74 | 0.83 | 0.83 | 0.84 | 0.87 | 0.88 | 0.88 | 0.90 |
| Feature 8 | 0.82 | 0.84 | 0.93 | 0.94 | 0.95 | 0.99 | 0.98 | 0.98 | 0.99 |
| Feature 16 | 0.92 | 0.90 | 0.98 | 0.99 | 0.99 | 0.99 | 0.87 | 0.75 | 0.99 |
| Feature 22 | 0.95 | 0.91 | 0.99 | 0.99 | 1.00 | 0.99 | 0.77 | 0.80 | 0.99 |
| Feature 27 | 0.95 | 0.91 | 0.99 | 0.99 | 1.00 | 0.99 | 0.87 | 0.67 | 0.99 |
| All Features | 0.96 | 0.91 | 0.99 | 0.99 | 1.00 | 0.99 | 0.81 | 0.67 | 0.99 |

**Mean F1-Score**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Feature | XGBoost | Decision Tree | Random Forest | Extra Trees | KNN | ANN | GRU | LSTM | Meta Learning |
| Feature 5 | 0.72 | 0.74 | 0.83 | 0.83 | 0.84 | 0.87 | 0.88 | 0.88 | 0.90 |
| Feature 8 | 0.81 | 0.84 | 0.93 | 0.93 | 0.95 | 0.99 | 0.98 | 0.98 | 0.99 |
| Feature 16 | 0.92 | 0.90 | 0.98 | 0.99 | 0.99 | 0.99 | 0.87 | 0.74 | 0.99 |
| Feature 22 | 0.94 | 0.91 | 0.99 | 0.99 | 1.00 | 0.99 | 0.77 | 0.79 | 0.99 |
| Feature 27 | 0.95 | 0.91 | 0.99 | 0.99 | 1.00 | 0.99 | 0.86 | 0.66 | 0.99 |
| All Features | 0.96 | 0.91 | 0.99 | 0.99 | 1.00 | 0.99 | 0.81 | 0.67 | 0.99 |

**Performance Comparison Using 16 Features**

|  |  |  |
| --- | --- | --- |
| Model | Accuracy | F1 Score |
| XGBoost | 0.92 | 0.92 |
| Decision Tree | 0.90 | 0.90 |
| Random Forest | 0.98 | 0.98 |
| Extra Trees | 0.99 | 0.99 |
| KNN | 0.99 | 0.99 |
| ANN | 0.99 | 0.99 |
| GRU | 0.87 | 0.87 |
| LSTM | 0.75 | 0.74 |
| Meta Learning | 0.99 | 0.99 |