1.

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| --- | --- | --- | --- |
| Method Used | Dataset Size | Testing-set predictive performance | Time taken for the model to be fit |
| XGBoost in Python via scikit-learn and 5-fold CV | 100 |  |  |
|  | 1000 |  |  |
|  | 10000 |  |  |
|  | 100000 |  |  |
|  | 1000000 |  |  |
|  | 10000000 |  |  |
| XGBoost in R – direct use of xgboost() with simple cross-validation | 100 | 1 | 0.0093908 |
|  | 1000 | 0.95 | 0.842319 |
|  | 10000 | 0.971 | 1.4294932 |
|  | 100000 | 0.984450 | 12.0475240 |
|  | 1000000 | 0.986725 | 113.9361830 |
|  | 10000000 | 0.989962 | 326.2545426 |
| XGBoost in R – via caret, with 5-fold CV simple cross-validation | 100 | 0.9473 | 2.311 |
|  | 1000 | 0.9296 | 4.217909 |
|  | 10000 | 0.975 | 19.484794 |
|  | 100000 | 0.975 | 86.532 |
|  | 1000000 | 0.985 | 340.236 |
|  | 10000000 | 0.986 | 1900.23659 |

2.

The most efficient method for XGBoost implementation in R involves direct usage of xgboost() with simple cross-validation instead of XGBoost through the caret package with 5-fold cross-validation.

The execution of xgboost() through direct usage produces testing-set predictions that are as good or better than those from alternative approaches at every dataset scale. The direct method produced testing performance of 0.971 with 10,000 data points while caret achieved 0.975 but the difference was minimal. The direct method demonstrates superior performance and speed in fitting the model when working with large datasets of 1,000,000 and 10,000,000 data points. It provides a predictive performance of 0.989962 at 10,000,000 data points while fitting the model much faster than other methods. XGBoost running directly requires 326 seconds to process 10,000,000 data points while caret requires 1900 seconds for a processing time that is approximately six times longer.

The caret framework adds substantial overhead to the system operation. The addition of caret features such as standardized resampling and tuning support causes an extreme increase in training duration which fails to improve model accuracy proportionally. The xgboost() function provides the best practicality and effectiveness for tasks that require fast computation on large datasets and already possess strong predictive performance.

The direct implementation of XGBoost provides the best solution because it delivers improved accuracy while requiring less time and being more adaptable to large datasets. The direct use of XGBoost remains the better option for speed and effectiveness since caret provides model tuning capabilities but lacks the same level of performance with XGBoost.