Appendix:

This document serves as an appendix to Evaluating algorithms for missing value imputation in real battery data. This appendix begins with a description of the experiment carried out, the summarised training and cross-validation results, as well as the results from the Mann-Whitney U test. The k-NN algorithm emerges as the best performing, demonstrating efficient learning and generalization across all features This paper has shown that ML algorithms can be used for MVI and error correction, with k-NN and MICE providing efficient, and reliable estimates to missing values, with minimal training effort.

MVI performance is very good on features with lower standard deviation and cardinality, while it remains unreliable on others. The categorical features *'Material Weight'* and *'Material Part Number'*, modeled as continuous features, also provide good results, further demonstrating the versatility of the imputation methods. These observations are critical for understanding the applicability and limitations of different imputation techniques for error correction in the HVB dataset. For further information and the conclusions drawn from these results, refer to [1].

1. Training Results

The training results in Figures 1-3 show the best performance for the *'Minimum Capacity'* feature. The average error in the larger training set is higher than in the cross-validation set, indicating robustness in performance.

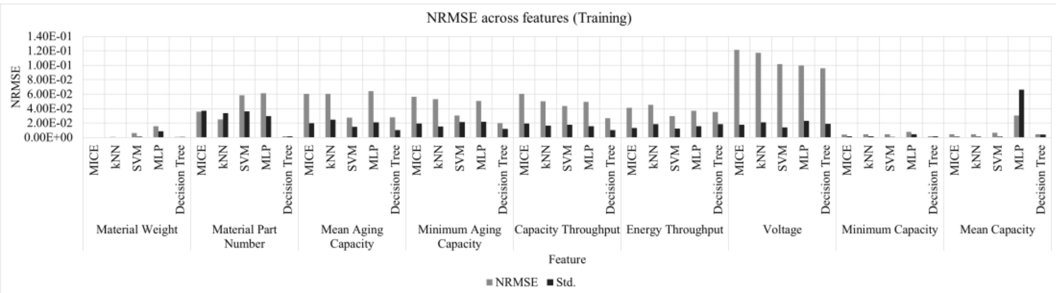

Figure 1: NRMSE across the continuous features during training.

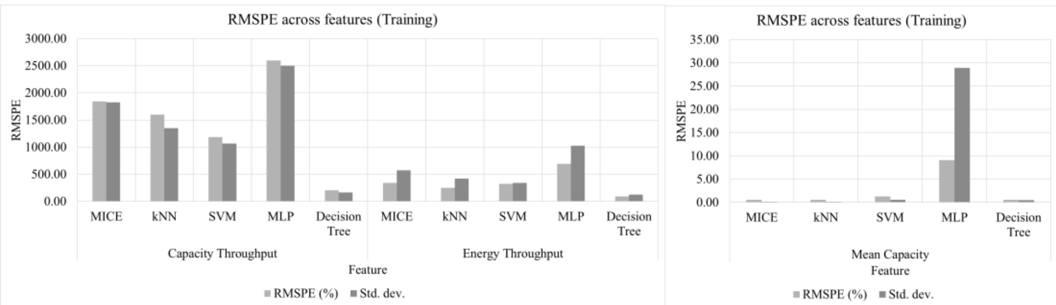

Figure 2: RMSPE for Capacity, Energy Throughput, and Mean Capacity during training.

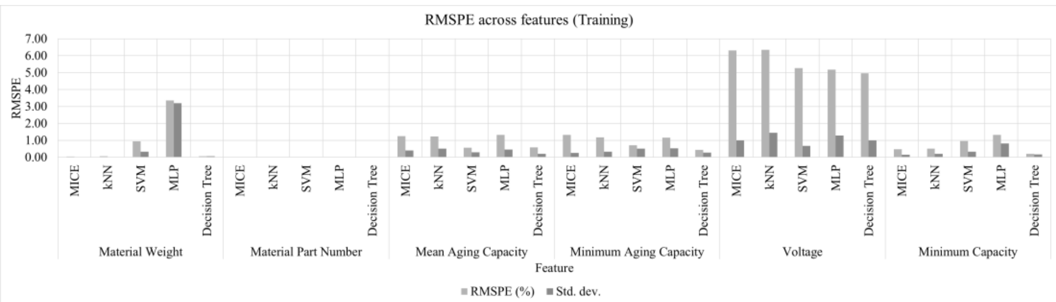

Figure 3: RMSPE across seven continuous features during training.

2. Cross-Validation Results

The cross-validation results are shown in Figures 3-6. The MICE and k-NN algorithms outperform the other algorithms, as in the training results. There is notable performance improvement in all algorithms.

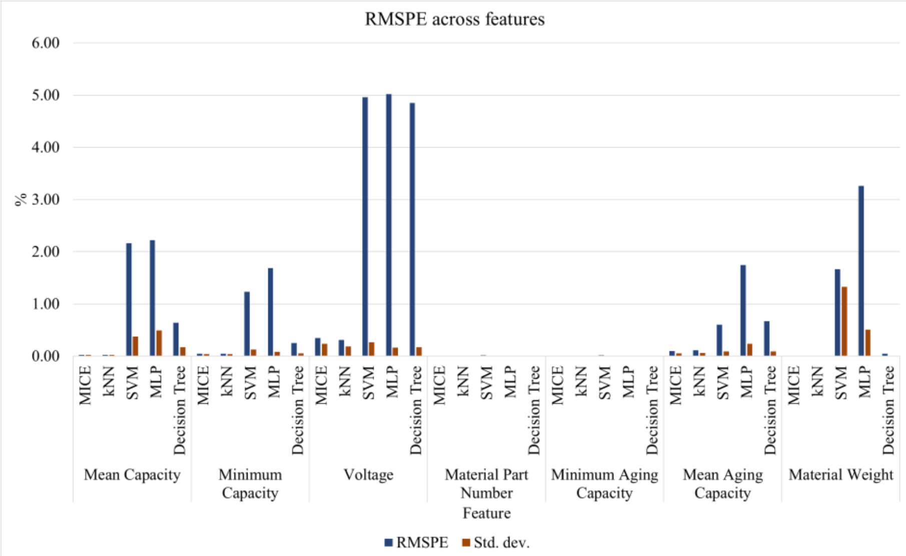

Figure 4: RMSPE across seven continuous features.

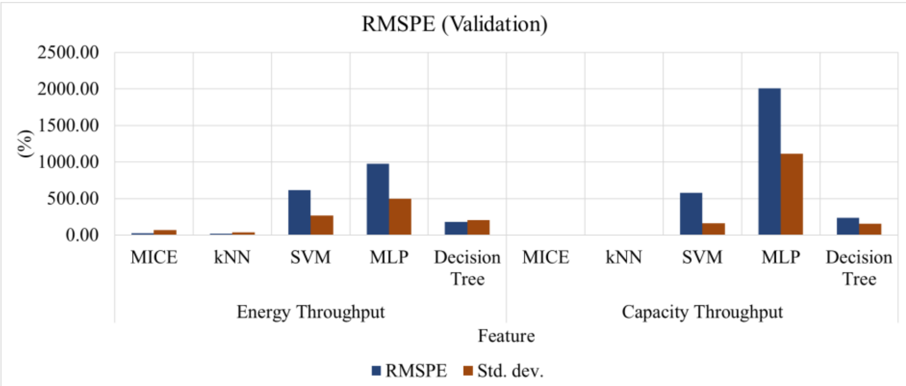

Figure 5: RMSPE for the Energy and Capacity Throughput features.

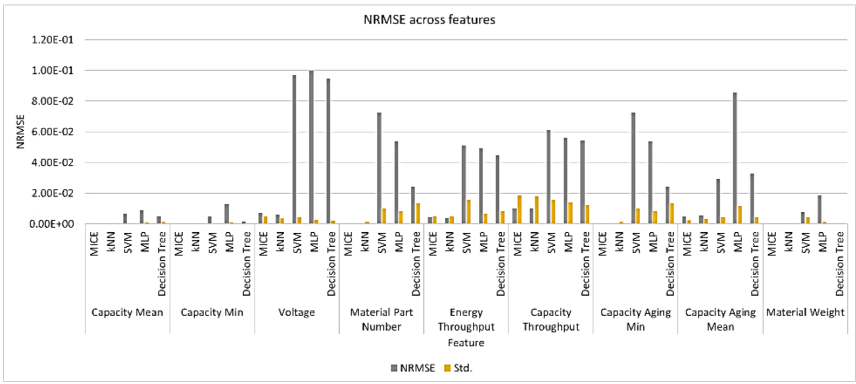

Figure 6: NRMSE across the continuous features in the dataset.

3. Mann-Whitney U Test

The Mann-Whitney U test revealed no statistical significance between the two imputation algorithms. In all other cases, the MICE and k-NN algorithm outperform the other three predictive algorithms. The results for the RMSPE and NRMSE metrics are shown in Tables 1 and 2, respectively.

Table 1: Mann-Whitney U Test on RMSPE for the continuous features

Material Part Number						***Voltage***					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	1	-1	MLP	-1	-1	0	0	0
SVM	-1	-1	-1	0	-1	SVM	-1	-1	0	0	0
Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	0	0	0
Capacity Min						***Capacity Mean***					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	1	-1	MLP	-1	-1	0	1	-1
SVM	-1	-1	-1	0	-1	SVM	-1	-1	-1	0	-1
Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	1	1	0
Capacity Throughput						***Energy Throughput***					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	-1	-1	MLP	-1	-1	0	-1	-1
SVM	-1	-1	1	0	-1	SVM	-1	-1	1	0	-1
Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	1	1	0
Capacity Aging Min						***Capacity Aging Mean***					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	-1	-1	MLP	-1	-1	0	-1	-1
SVM	-1	-1	1	0	-1	SVM	-1	-1	1	0	0
Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	1	0	0

Table 2: Mann-Whitney U Test on NRMSE for the continuous features

Material Part Number						***Voltage***					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	1	-1	MLP	-1	-1	0	-1	-1
SVM	-1	-1	-1	0	-1	SVM	-1	-1	1	0	0

Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	1	0	0
Minimum Capacity						Mean Capacity					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	-1	-1	MLP	-1	-1	0	-1	-1
SVM	-1	-1	1	0	-1	SVM	-1	-1	1	0	-1
Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	1	1	0
Capacity Throughput						Energy Throughput					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	0	0	MLP	-1	-1	0	0	0
SVM	-1	-1	0	0	0	SVM	-1	-1	0	0	0
Decision Tree	-1	-1	0	0	0	Decision Tree	-1	-1	0	0	0
Minimum Aging Capacity						Mean Aging Capacity					
	MICE	kNN	MLP	SVM	Decision Tree		MICE	kNN	MLP	SVM	Decision Tree
MICE	0	0	1	1	1	MICE	0	0	1	1	1
kNN	0	0	1	1	1	kNN	0	0	1	1	1
MLP	-1	-1	0	-1	-1	MLP	-1	-1	0	-1	-1
SVM	-1	-1	1	0	-1	SVM	-1	-1	1	0	0
Decision Tree	-1	-1	1	1	0	Decision Tree	-1	-1	1	0	0

[1] Sheni, D.N., Basson, A.H., Grobler, J.: Evaluating algorithms for missing value imputation in real battery data. (2024, forthcoming).