Decision Support in Maintenance for Components in Electrical Power Distribution Networks

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1. Model Construction

Networked microgrid is two or more microgrids interconnected at the physical layer through the electrical power distribution network and at the communications and control layers. However, the components in the distribution network, a key element of the networked microgrids, are deteriorating, and thus, it is crucial to maintain their condition efficiently. The authors propose a decision tree-based support model that utilizes accumulated records to predict the necessity of replacing distribution power components in a networked microgrid.

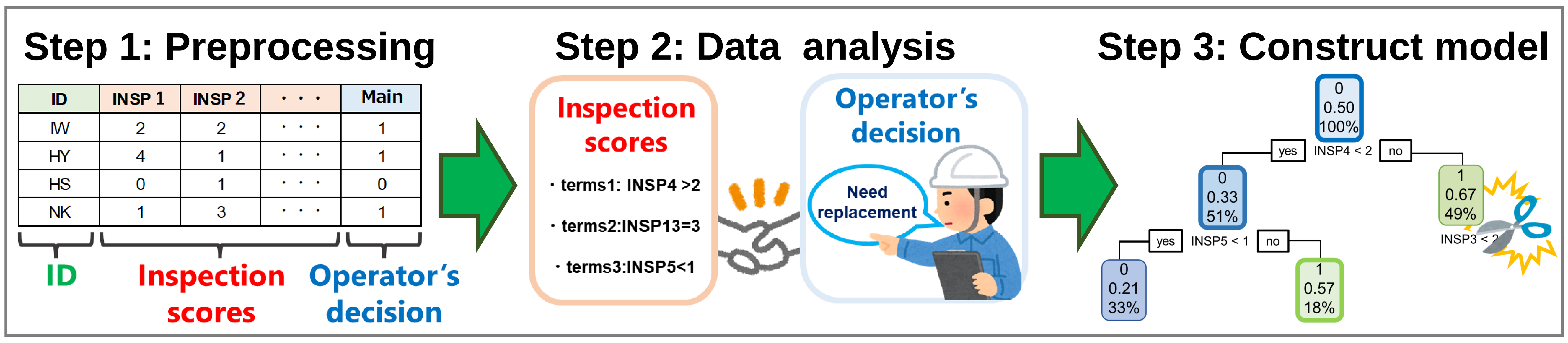
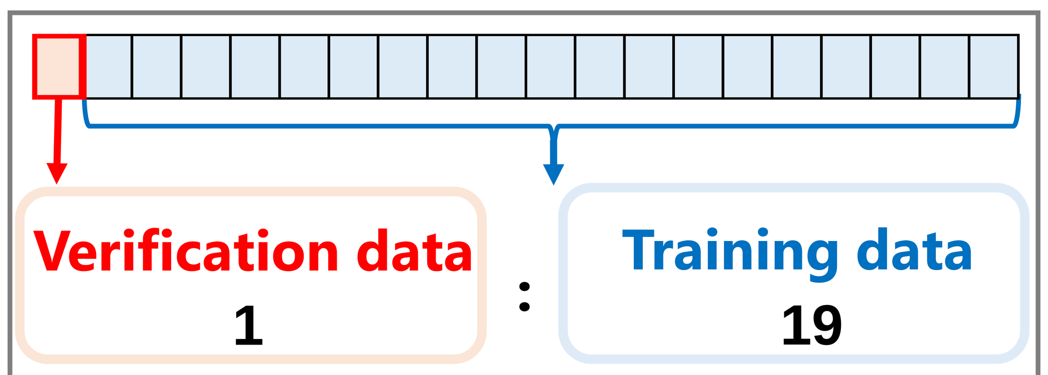


Figure 1. Process for constructing.



The number of extract data of concrete utility poles and pole transformers is following.

- Concrete utility poles: 16,246
- Pole transformers: 7,566

Figure 2. Classification of extract data for constructing model.

By using decision tree learning,

Step 1: Extract inspection scores and maintenance decisions from the records of inspection and maintenance and create training dataset with its results.
Step 2: Analyze the dataset to identify the criteria by which operators made replacement decisions.
Step 3: Construct a tree-like classification model (decision tree) through the process of 'growth' and 'pruning' associated with the identified criteria.

2. Numerical Simulations

The constructed decision trees are evaluated using the following three indices.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \times 100 \text{ , } Recall = \frac{TP}{TP \times FN} \times 100 \text{ , } Precision = \frac{TP}{TP+FP} \times 100$$

- *Accuracy* represents the rate of decision tree predictions that matched decisions of the operators.
- *Recall* represents the rate at which the decision tree assessed "replacement required" for actually replaced components.
- *Precision* represents the rate at which the decision tree assessed "replacement required" for actually operable components.

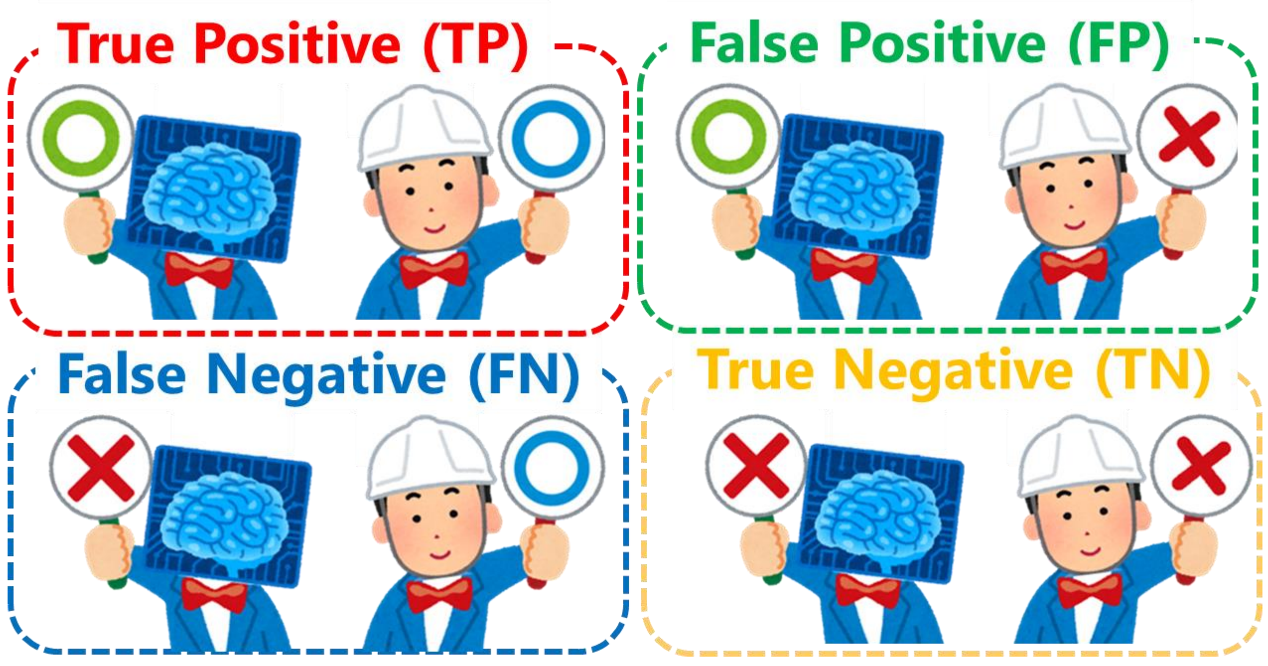


Figure 3. Image of TP, FP, FN, and TN.

Result for Concrete utility poles

Table 1. Application results.

Accuracy	Recall	Precision
82.3%	84.1%	81.4%

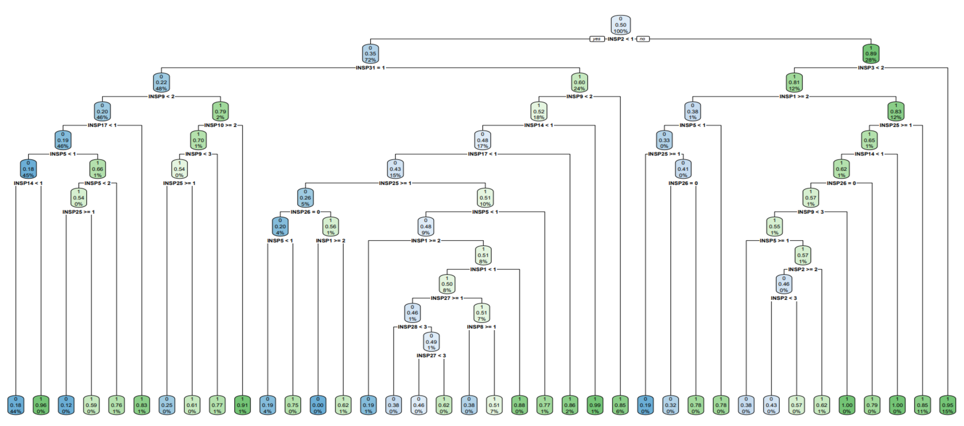


Figure 4. Constructed model.

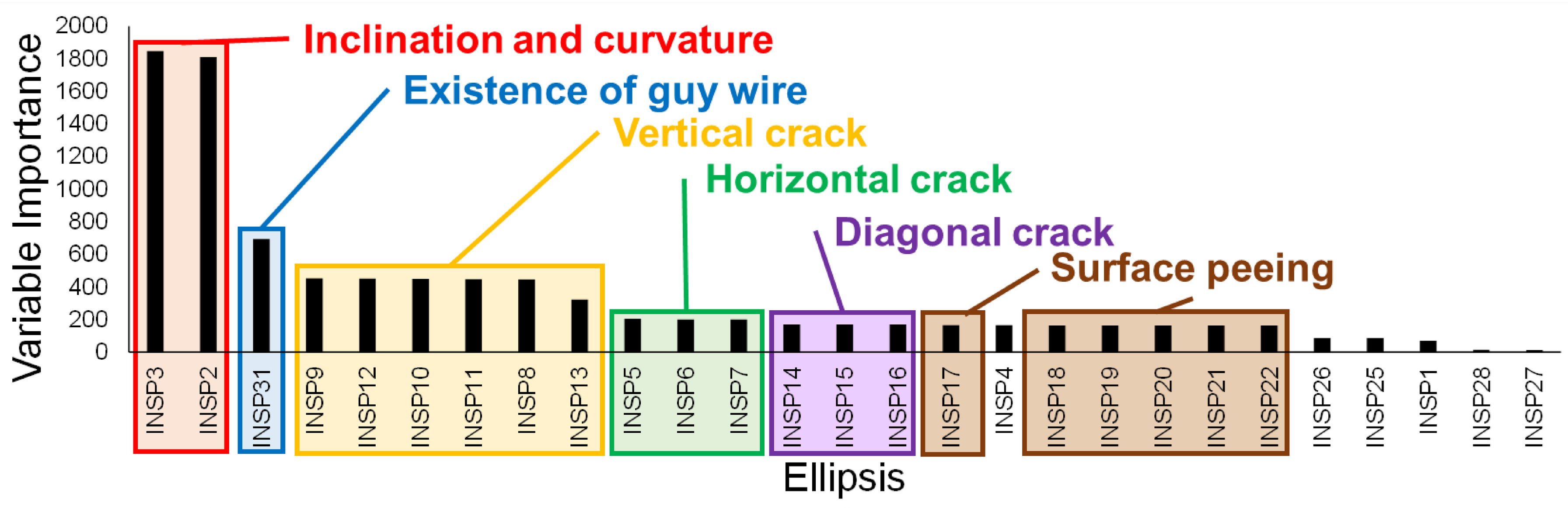


Figure 5. Variable importance for concrete utility poles.

Result for Pole transformers

Table 2. Application results.

Accuracy	Recall	Precision
68.6%	88.7%	61.3%

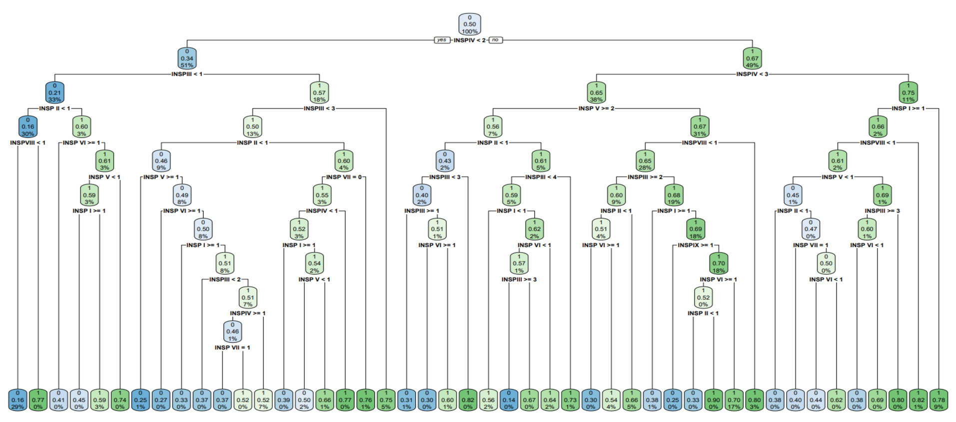


Figure 6. Constructed model.

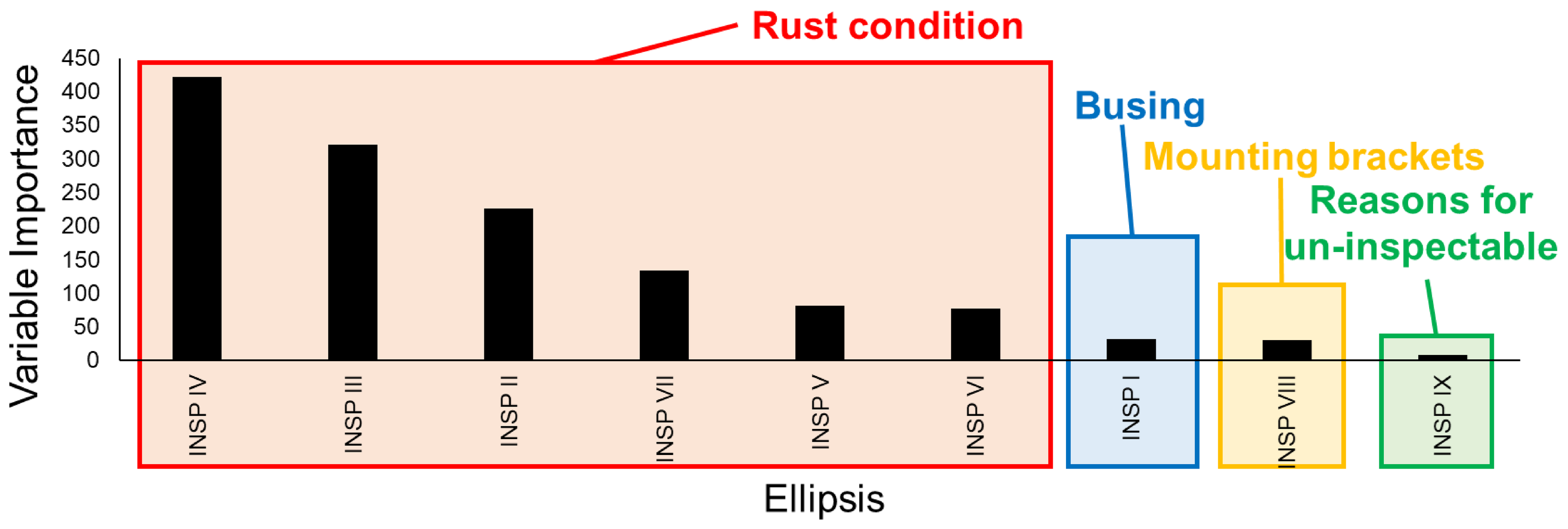


Figure 7. Variable importance for pole transformers.

Recall, which is a key index in terms of maintaining the reliable operations of the networked microgrid, exceeded 80% in both components. In addition, variable importance mostly matched operator's knowledge and experience.

=> The proposed model functions well, and the authors conclude that the proposal can support in decision-making of maintenance necessity in the networked microgrids.

3. Conclusion

The authors proposed a model that determines if the electrical components in a networked microgrid needs to be replaced.
This model was constructed by "a simple decision tree learning" but showed reasonable prediction accuracy .