RF Research

Fabio Rougier

March 13, 2022

Contents

1 Master thesis from Eindhoven

This (Kuznetsova et al., 2014) is a master's thesis

1.1 Remarks

The author uses an entire chapter to describe in detail how a random forest works. It's definitely not a good thesis, judging by the wording. However, it might hold some value from its content...

1.2 Points to note

- Prototypes: On p 11 the author mentions the idea of prototypes for every class and attribute
- Different consumers: On p 14 the author emphasizes the different approach to ML, data and its different consumers. While the ML expert is more focused on improving his model performance (and it's indicating variables.), the Analyst/Domain Expert is more concerned about the insights that the model yields (attributes, instances, noise,).
- RAFT: Random Forest Tool by Breimann is introduced as an existing tool for RF visualisation, authors conclusion is that tool is best with small amount and exclusively numerical attributes
- Small multiples: Mentioned in her source n16 (Tufte, 1985)
- Visualization considerations: p20/21 lists concise considerations for the Visualization of the RF following the principle of small multiples
- ReFINE: Tool developed by the author, looks promising

1.3 Summary

Overall, a mediocre thesis, but all the more interesting and extensive software and approach. Note that it is from 2014 which is likely why the author uses java.

2 Breimann Implementation Paper

This (Livingston, 2005) is a paper on a particular implementation on the RAFT software of Breimann.

2.1 Remarks

The paper seems to be concerned about the specifics of how a RF is created. Using RFs for problems where a very rare occasion has to be trained often results in bad models, because the training set is already heavily scewed towards the "regular" case and so the detection of edge cases seems to be a problem for such models. They do use the RAFT software but the paper is likely not focusing on the specifics of RF Visualization. Additionally the paper is from 2005, so it is quite outdated. They use Fortran and Java ...

2.2 Points to note

- Weka: Some kind of java program
- Variable Importance: The authors implemented variable importance into Weka

2.3 Summary

Very old paper and the specifics will unlikely be relevant today, however it might contain very important references that I can use!

3 Explainable Matrix paper

This (Neto & Paulovich, 2020) is a journal article presenting ExMatrix - a visualization method trying to convey the configuration of a model in a matrix structure.

3.1 Remarks

This paper is from 2021 and therefore far more relevant than the others. It also specifically focuses on the problematics of RFs.

3.2 Points to note

Model interpretability: The main problem statement is the lack of interpretability of models and their decisions despite being accurate. A 99% accuracy does not convince anyone, if there is no explanation for the decision.

Global/Local approaches: Global explains the entire model, trying to improve the trust in the models' decision making. Local explains the decision behind a single instance.

pre-/in-/post-model strategies: For which stage of the ML process is the visualization helpful?

BaobabView: This is a node-link explanation technique (Van Den Elzen & Van Wijk, 2011), down below. But node-link visualization has scalability issues.

RuleMatrix: The technique has been used before (Ming, Qu, & Bertini, 2018).

Decision Paths: Focus of the visualization is on decision paths, rather than nodes.

Surrogates: Sometimes RFs are used as a *surrogate* for a less interpretable model.

iForest: Also closely related to ExMatrix (Zhao, Wu, Lee, & Cui, 2018), summarizes decision paths.

Trying to explain the visualization specifics, because I think, this is an incredibly valuable paper for me: Every path is translated into a rule vector, consisting of as many coordinates, as there are features along the path. Each rule consists of *predicates* which represent single decisions on attribute values. For each rule vector there is a rule certainty (for each class, adding up to 100%), which represents how accurately the respective path classifies the instances that came along its path. The rule vector class is the class that has the highest value in the rule certainty. Rule coverage is the percentage of instances of the training data of class c for which the rule *works*. The 2nd graphic is the LE (Local Explanation) / UR (Used Rules) visualization and focuses on a single instance. Each features decision boundaries are layed out, with a pointed line, representing the given instance. There is an additional column *cumulative voting* next to the rule certainty, which sums the certainties up to the respective row, starting from the top. The 3rd graphic is the

LE / SC (smallest changes) visualization. It visualizes the smallest necessary rule change to change the classification of the displayed sample.

3.3 Summary

Extremely relevant paper with lots of potential references and ideas. This could even be a visualization to build my own visualization upon. The authors noted in their own conclusion, that especially the LE/SC visualization leaves quite some room for improvement. The general idea of breaking down the RF into single rules is also interesting. The code is on github and a forked version would be an option. However, the github was not updated since last year April. I could consider contacting the authors if I pursue any further ideas along their approach.

4 BaobabView

(Van Den Elzen & Van Wijk, 2011)

4.1 Remarks

4.2 Points to note

4.3 Summary

5 Matrix Visualization

(Ming et al., 2018)

5.1 Remarks

5.2 Points to note

5.3 Summary

6 iForest

(Zhao et al., 2018)

6.1 Remarks

6.2 Points to note

6.3 Summary

References

Kuznetsova, N., Westenberg, M., Buchin, K., Dinkla, K., & van den Elzen, S. (2014). Random forest visualization. *Eindhoven University of Technology*.

Livingston, F. (2005). Implementation of breiman's random forest machine learning algorithm. *ECE591Q Machine Learning Journal Paper*, 1–13.

Ming, Y., Qu, H., & Bertini, E. (2018). Rulematrix: Visualizing and understanding classifiers with rules. *IEEE transactions on visualization and computer graphics*, *25*(1), 342–352.

Neto, M. P., & Paulovich, F. V. (2020). Explainable matrix-visualization for global and local interpretability of random forest classification ensembles. *IEEE Transactions on Visualization and Computer Graphics*, *27*(2), 1427–1437.

Tufte, E. R. (1985). The visual display of quantitative information. *The Journal for Healthcare Quality (JHQ)*, *7*(3), 15.

Van Den Elzen, S., & Van Wijk, J. J. (2011). Baobabview: Interactive construction and analysis of decision trees. In *2011 ieee conference on visual analytics science and technology (vast)* (pp. 151–160).

Zhao, X., Wu, Y., Lee, D. L., & Cui, W. (2018). iforest: Interpreting random forests via visual analytics. *IEEE transactions on visualization and computer graphics*, *25*(1), 407–416.