

Statistical methods for clinical decision making: Trees and rules

December 2012 FSW Data Science seminar

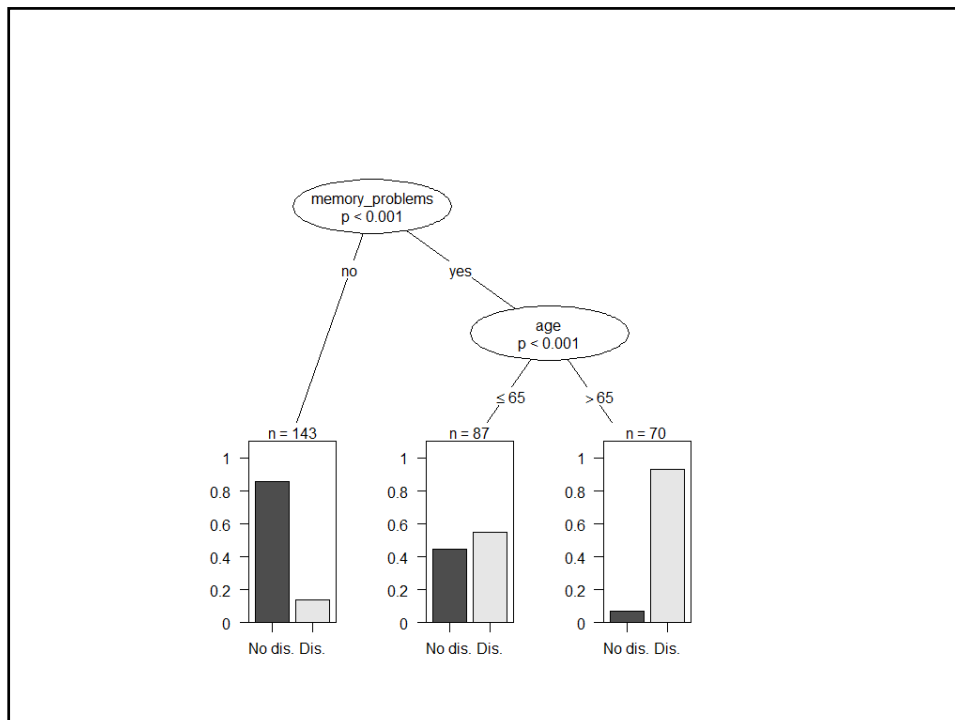
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Recursive partitioning methods

... recursively partition the observations in a dataset based on their predictor variable values...

... into subgroups that are as similar as possible in terms of their values on the response variable.

Subgroups can be depicted as a decision tree:



Advantages

- Predictor variables can be categorical, ordinal, continuous
- No (or few) assumptions about the data distribution
- Automatically accommodate interactions and non-linear effects
- Can deal with many potential predictor variables
- Direct identification of subgroups
- Easy to use in decision making

Data example I

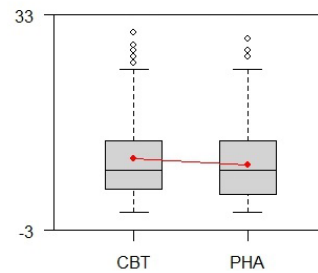
Pooled data from 7 RCTs on depression treatments (N=694)

- Cognitive Behavioral Therapy (CBT)
- Pharmacotherapy (PHA)

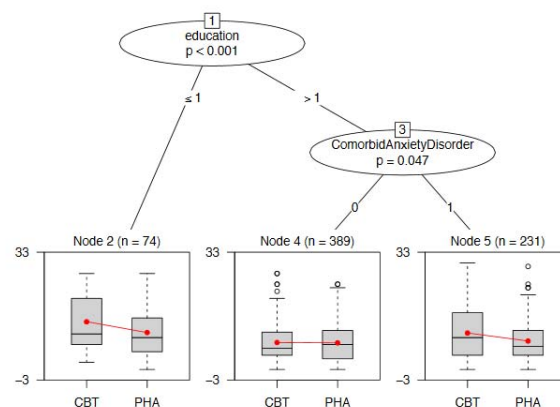
Outcome: post-treatment depression rating scale

Potential moderators of treatment effect:

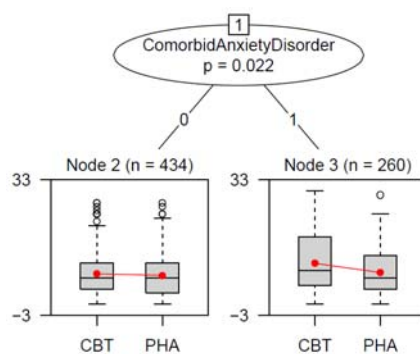
- Age
- Gender
- Level of education
- Pre-treatment depression
- Comorbid anxiety disorder
- ...



Linear model trees (Zeileis, Hothorn & Hornik, 2008)



Linear mixed-effects regression trees (Fokkema et al., 2018)



Linear mixed-effects regression tree (Fokkema et al., 2018)

Simulation study (Fokkema et al., 2018):

- Higher accuracy and lower complexity than linear mixed-effects regression models
- linear model trees



Implemented in **R** package **glmertree** (Zeileis & Fokkema, 2017)

Single trees

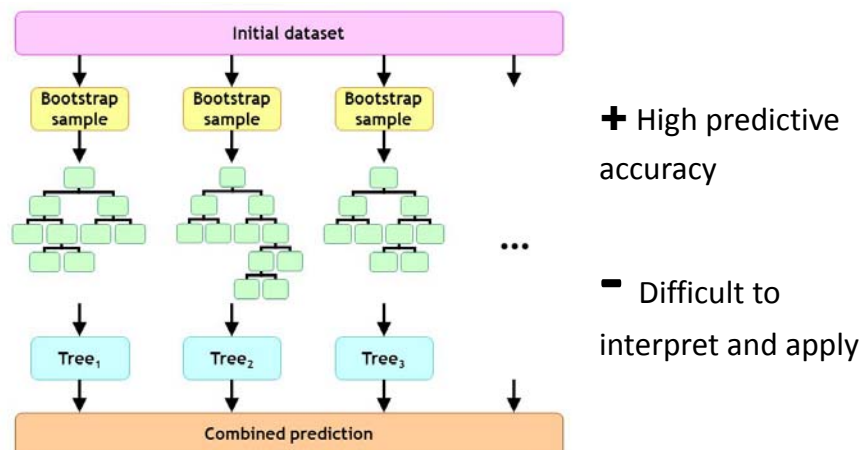
Good: Easily interpretable and applicable

Bad: Not most accurate method

Ugly: Unstable



Tree ensembles



Prediction rule ensembles

Rulefit algorithm (Friedman & Popescu, 2008):

- 1) Start with full ensemble of decision trees
- 2) Code every node from every tree as a rule
→ a dummy variable, equals 1 if observation is a member of the node, 0 if not.
- 3) Select small subset of rules by sparse regression (e.g., lasso, ridge or elastic net)

Data example II

Penninx et al. (2006): Risk of chronic trajectory among patients with current depressive and/or anxiety disorders (N = 1209)

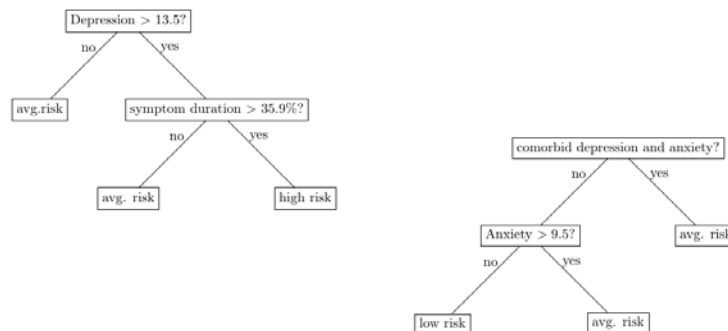
6 significant predictors in logistic regression:

- Presence of comorbid disorder
- Age
- Depression questionnaire score
- Anxiety questionnaire score
- Age at onset of disorder
- Agoraphobia

Prediction rule ensemble

Fokkema et al. (2015): Applied Rulefit to same data, same question

Result: two rules predicting chronicity:



Comparison

	Logistic regression	RuleFit ensemble
Complexity	6 significant predictors	2 rules (4 binary cues)
Accuracy	.659	.653
Sensitivity	.782	.782
Specificity	.463	.447

Fitting prediction rule ensembles

Rulefit software

- Little documentation and flexibility
- Continuous and binary responses only
- Employs biased tree induction algorithm

New R package: **pre** (Fokkema & Christoffersen, 2017)

- Well-documented and more flexible
- For continuous, count, binary, multinomial, multivariate and survival responses
- Employs unbiased tree induction algorithms

Does **pre** kill the bad?
Does the good survive?



Fokkema (accepted):

- Accuracy: random forests > pre > rulefit > single trees
- Sparsity: single trees > pre > rulefit > random forests

Thank you for your attention!

Mixed-effects model trees:

Fokkema, M., Smits, N., Zeileis, A., Hothorn, T. & Kelderman, H. (2018). Detecting treatment-subgroup interactions in clustered data with generalized linear mixed-effects model trees. *Behavior Research Methods*, 50(5), 2016-2034. <http://link.springer.com/article/10.3758/s13428-017-0971-x>.

Zeileis, A. & Fokkema, M. (2017). glmertree: Generalized Linear Mixed Effects Model Trees. Available from CRAN and https://r-forge.r-project.org/R/?group_id=261.

Zeileis, A., Hothorn, T., & Hornik, K. (2008). Model-based recursive partitioning. *Journal of Computational and Graphical Statistics*, 17 (2), 492-514.

Prediction rule ensembles:

Fokkema, M. (accepted). [pre: An R Package for Fitting Prediction Rule Ensembles](#). *Journal of Statistical Software*. preprint: <https://arxiv.org/abs/1707.07149>

Fokkema, M. & Christoffersen, B. (2017). pre: Prediction Rule Ensembles. Available from CRAN and <https://github.com/marjoleinF/pre>.

Fokkema, M., Smits, N., Kelderman, H., & Penninx, B. W. (2015). Connecting clinical and actuarial prediction with rule-based methods. *Psychological Assessment*, 27(2), 636.

Friedman, J. H., & Popescu, B. E. (2008). Predictive learning via rule ensembles. *The Annals of Applied Statistics*, 2(3), 916-954.

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