Practical Predictive Analytics Seminar

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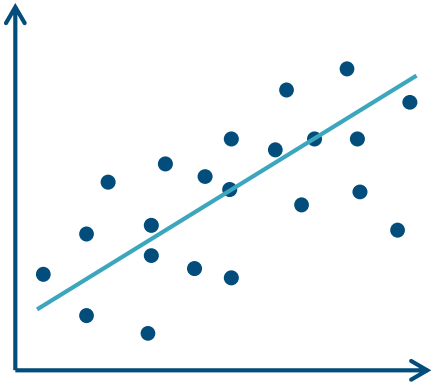
Session 4: Machine Learning Topics

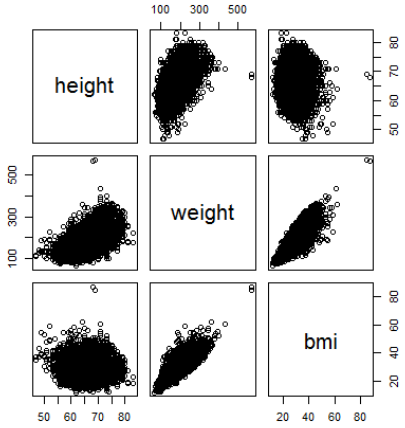
May 22, 2019

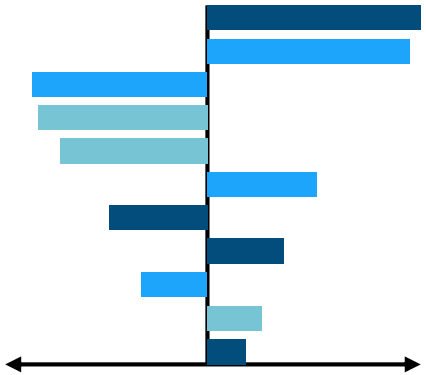
SOCIETY OF ACTUARIES

GLM review

- Linear model
- Interpretable
- Issues:
  - Multicollinearity
  - Variable selection
  - Variable importance
  - Interactions





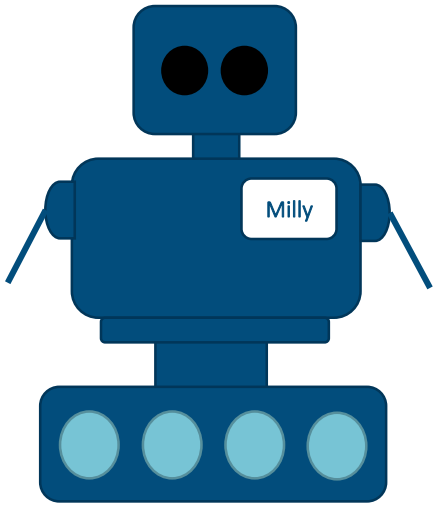


Why machine learning?

- Data continues to grow
- Powerful
- Flexible
- Computational enhancements
  - Cheaper
  - More available
- It's sexy

Machine learning techniques

- Regularization methods
- Classification and regression trees
- Ensemble models
- Others:
  - Clustering
  - Bayesian
  - Neural network
  - Deep learning



Regularization Methods

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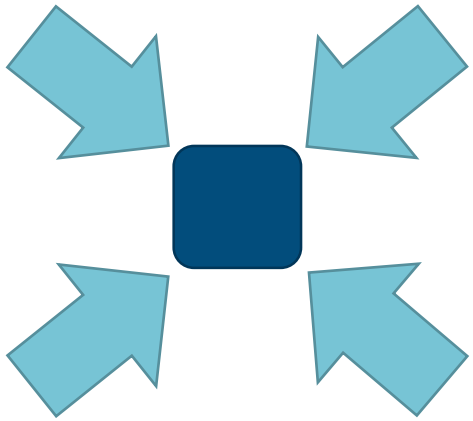
What is “regularization”?

- Regularization is a technique used to avoid the problem of overfitting. The idea is to add a complexity term to the loss function to penalize more complex models.



Regularization methods

- Ridge regression
- LASSO
- ElasticNet

- In R:
  - Packages: **glmnet**, MASS, ridge, lars, elasticnet, …

Ridge regression

- weight decay
- L2-norm penalty
- $loglikelihood =$

$$-\sum [Y_i \ln(\hat{y}_i) + (1 - Y_i)\ln(1 - \hat{y}_i)] + \boldsymbol{\lambda} \sum \boldsymbol{\beta^2}$$

LASSO

- Least absolute shrinkage and selection operator
- L1-norm penalty
- $loglikelihood =$

$$-\sum[Y_i \ln(\hat{y}_i) + (1 - Y_i)\ln(1 - \hat{y}_i)] + \boldsymbol{\lambda}\sum|\boldsymbol{\beta}|$$

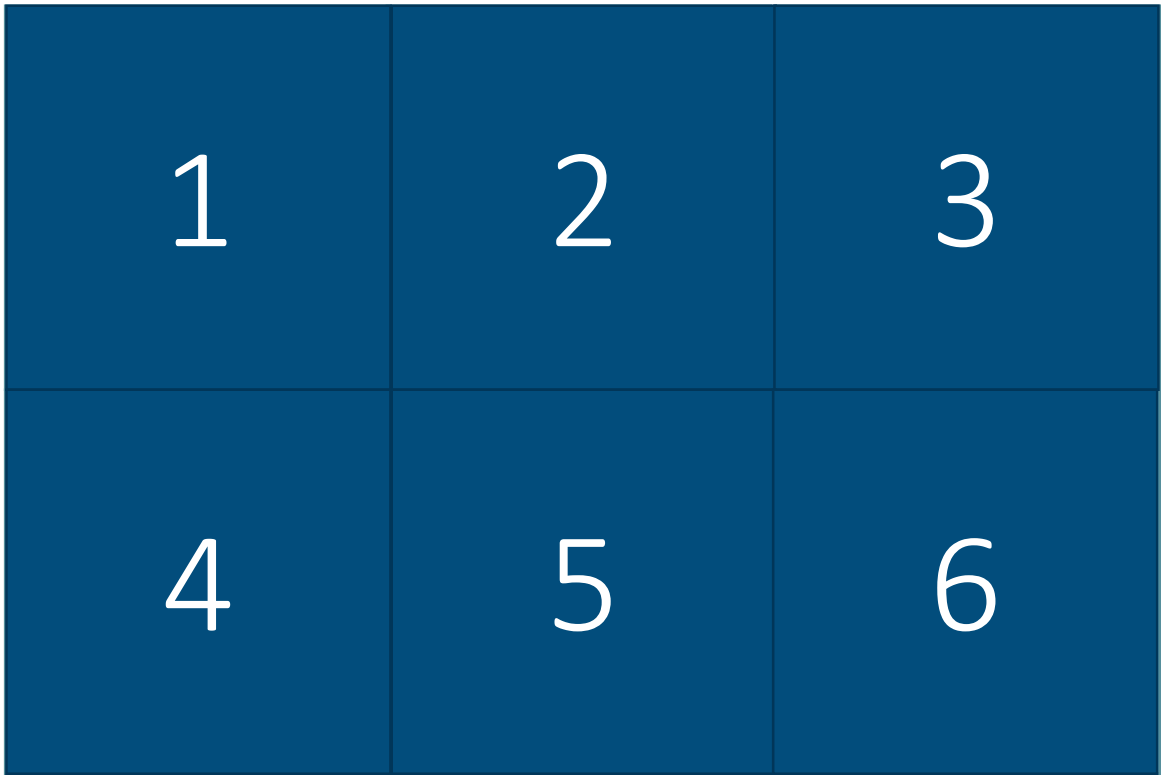
ElasticNet

- Convex combination of ridge and LASSO
- L2 & L1-norm penalties
- $loglikelihood =$

$$-\sum[Y_i \ln(\hat{y}_i) + (1 - Y_i)\ln(1 - \hat{y}_i)] + \boldsymbol{\lambda}\left((\mathbf{1} - \boldsymbol{\alpha})\sum \boldsymbol{\beta}^{\mathbf{2}} + \boldsymbol{\alpha}\sum |\boldsymbol{\beta}|\right)$$

Aside: Cross-Validation

- Useful for smaller datasets



Classification and Regression Trees (CART)

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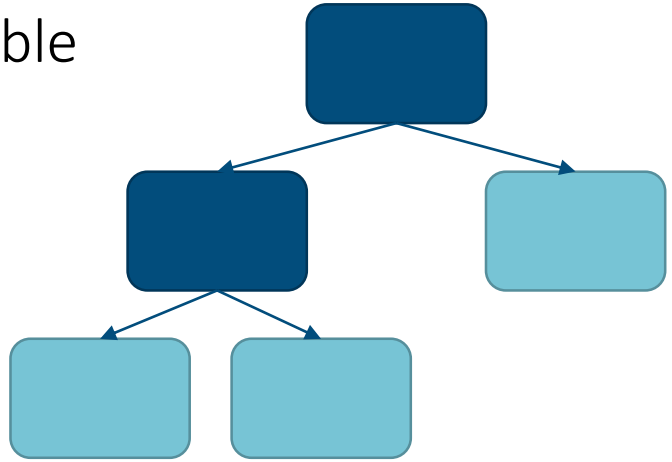
Trees

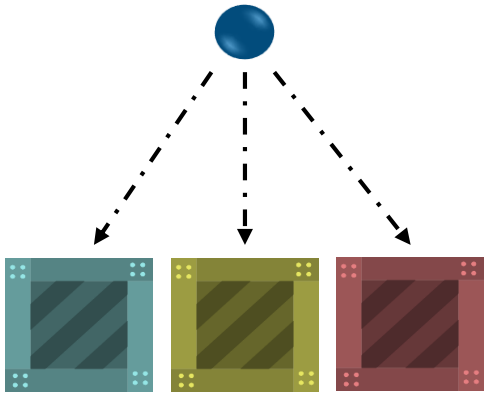
- Sequence of questions/rules for splitting the data
- Elements of CART algorithms
  - Rules for splitting data at each node
  - Stopping criteria
  - Prediction for the target variable

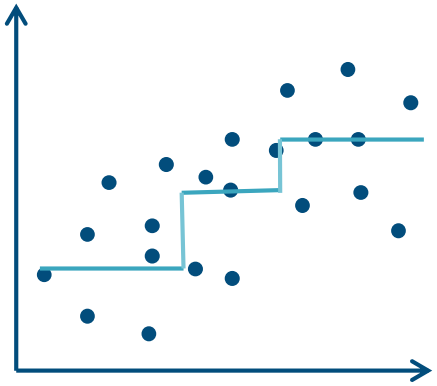
N = 350
0 = 200/350
1 = 150/350



Classification vs regression

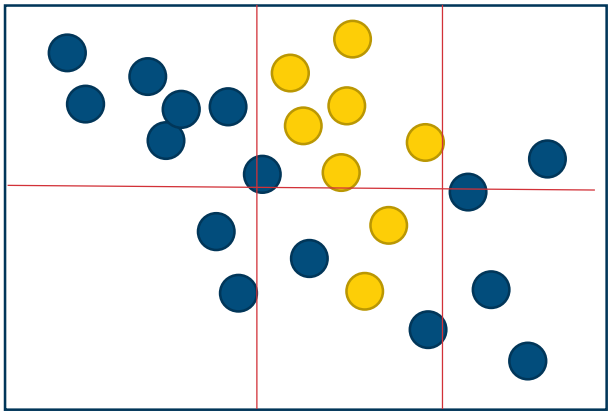
- Classification trees: used for categorical or binary target variables
  - Predict the category a policy will fall into
- Regression trees: continuous target variable
  - Predict the value of the continuous target





Splitting nodes

- Goal: choose the split that results in nodes with maximum homogeneity
- Classification: “Impurity” function
  - Entropy
  - Misclassification rate
  - Gini index
  - Twoing
- Regression: Squared residuals minimization



Stopping rules

- Depth
- Size
- Number of nodes
- Complexity parameter

Ensemble Models

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Overview

- What:
  - An ensemble model is the aggregation of two or more related but different models, averaged into a single prediction.

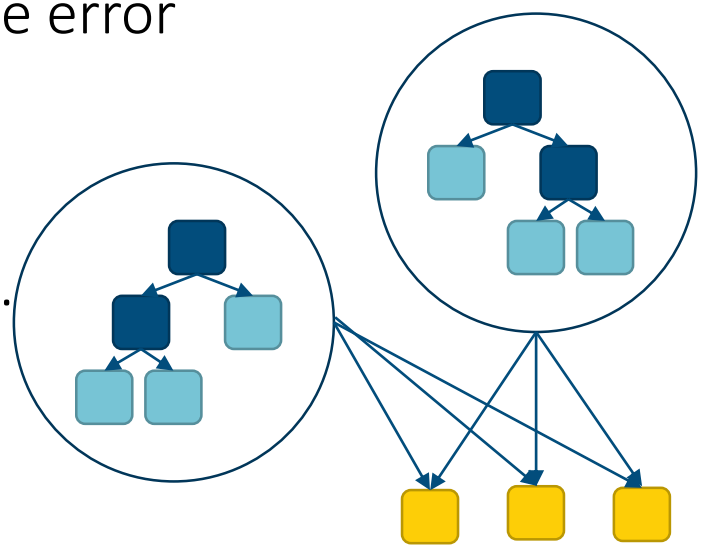
- Why:
  - Improve accuracy of predictions
  - Improve stability of the model

Ensemble methods

- Bagging
- Boosting
- Stacking

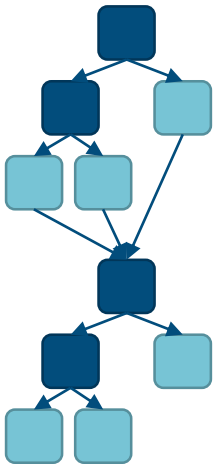
Bagging

- What is it:
  - Building multiple models from different subsamples of the training dataset, results are then combined for the final prediction.
  - Helps to reduce the variance error
- Example:
  - Random Forest
  - R package: **randomForest**, …



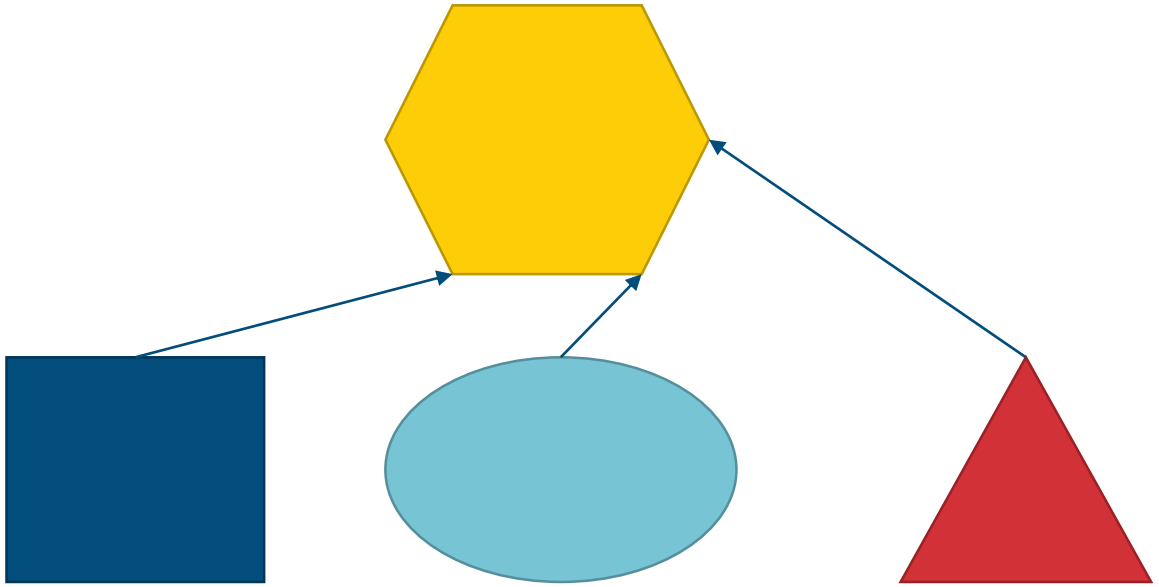
Boosting

- What is it:
  - Building multiple models, each of which is built to improve the prediction errors of a prior model
  - Has shown better predictive accuracy than bagging, but more likely to overfit
- Example:
  - Gradient Boosted Machines (GBM)
  - R packages: **gbm**, xgboost, …



Stacking

- What is it:
  - Building multiple models, typically different types of models, then having a supervisor model that determines how to best combine those results



Back to R!

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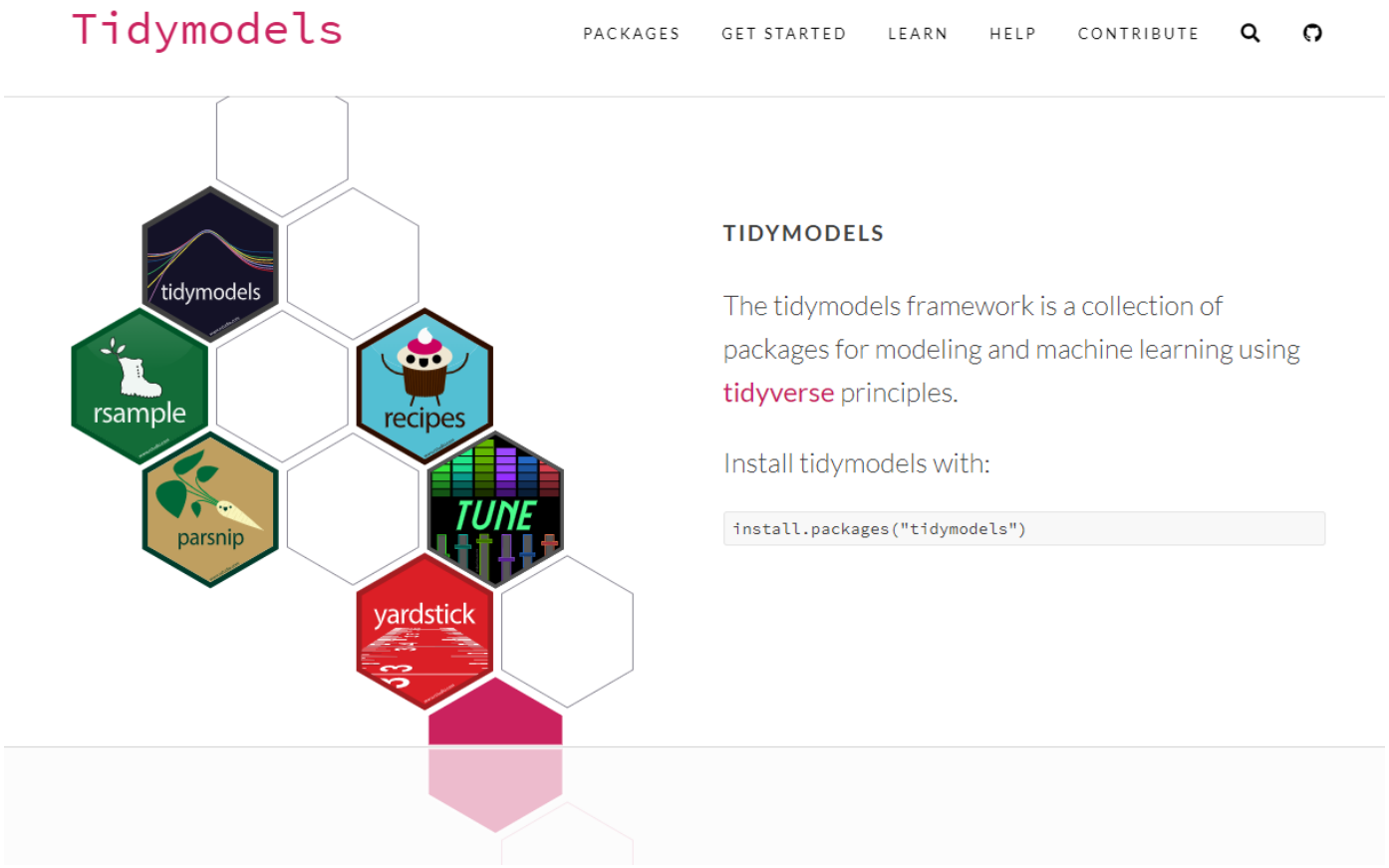
Tidymodels (tidymodels.org)



Final Thoughts

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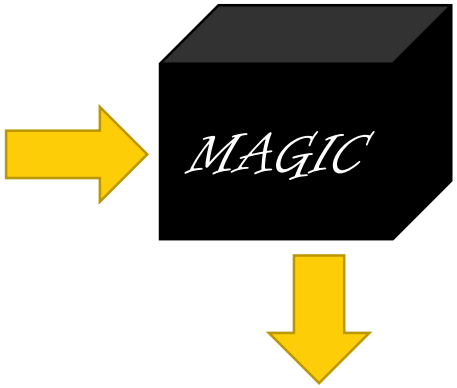
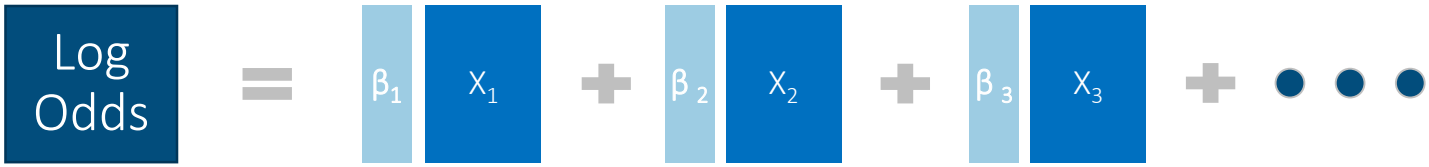
Weighing your options

- Implementation
- Explanation
- Cost





Other considerations

- Actuarial judgment
- Model selection
- Data issues
- Hardware/Software

Now you're on your way!