Boosting

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Basic idea

1. Take lots of (possibly) weak predictors
2. Weight them and add them up
3. Get a stronger predictor

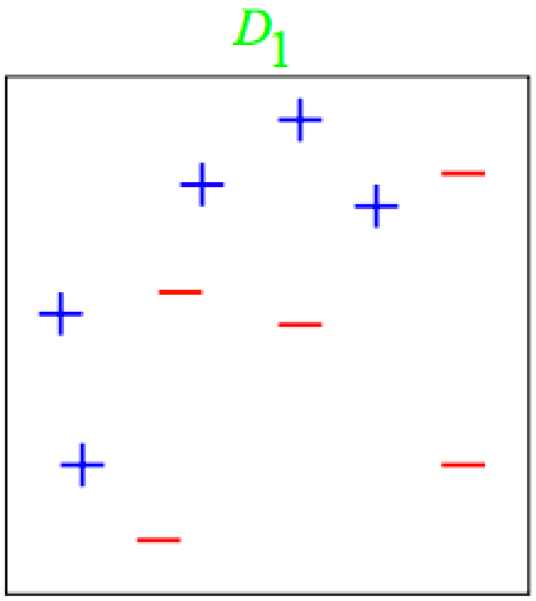
Basic idea behind boosting

1. Start with a set of classifiers $h_1, \ldots, h_k$
   - Examples: All possible trees, all possible regression models, all possible cutoffs.
2. Create a classifier that combines classification functions: $f(x) = \mathrm{sgn}\left(\sum_{\mathrm{t}=1}^{\mathrm{T}} \alpha_{\mathrm{t}} \mathrm{h}_{\mathrm{t}}(\mathrm{x})\right)$.
   - Goal is to minimize error (on training set)
   - Iterative, select one h at each step
   - Calculate weights based on errors
   - Upweight missed classifications and select next h

Adaboost on Wikipedia

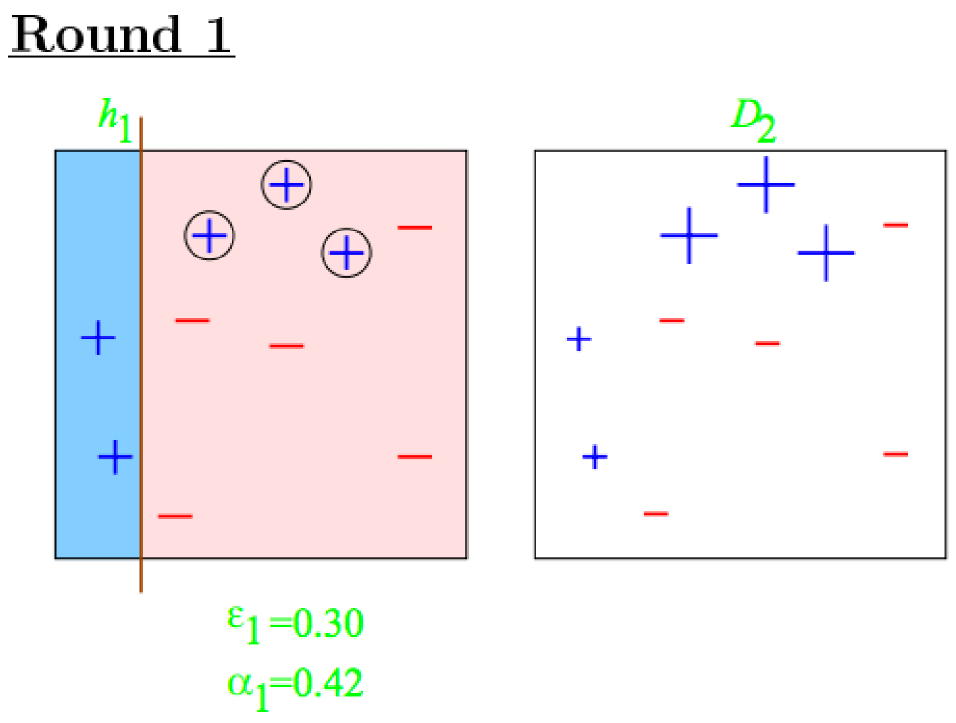
http://webee.technion.ac.il/people/rmeir/BoostingTutorial.pdf

Simple example



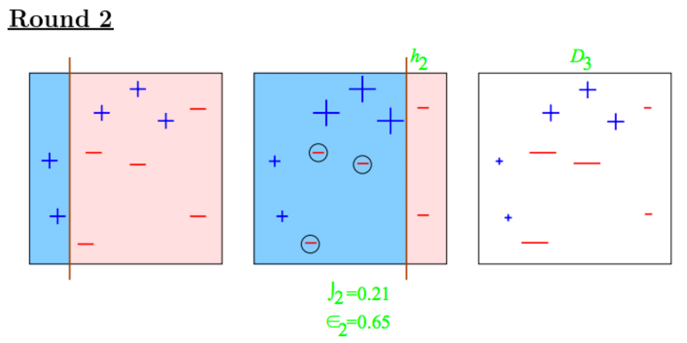
http://webee.technion.ac.il/people/rmeir/BoostingTutorial.pdf

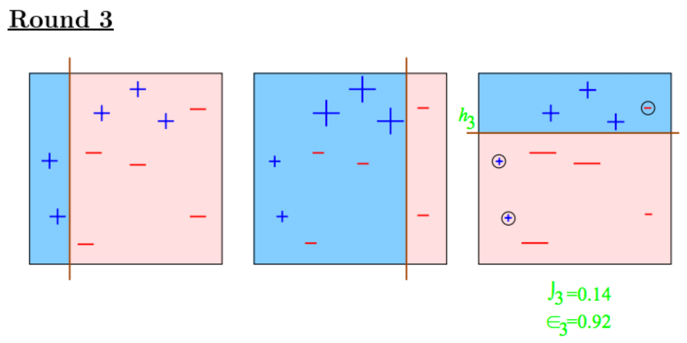
Round 1: adaboost



http://webee.technion.ac.il/people/rmeir/BoostingTutorial.pdf

Round 2 & 3





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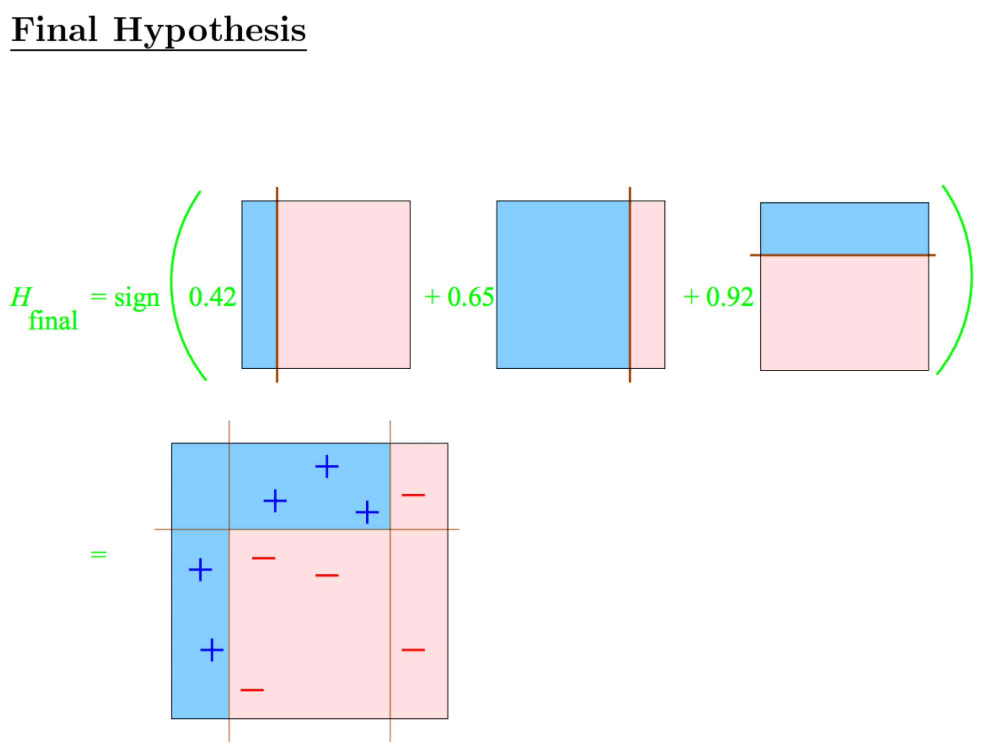
Completed classifier


Final Hypothesis
$H_{\text{final}} = \text{sign}\left(0.42 \; + 0.65 \; + 0.92\right)$
=
+
−

http://webee.technion.ac.il/people/rmeir/BoostingTutorial.pdf

Boosting in R

- Boosting can be used with any subset of classifiers
- One large subclass is gradient boosting
- R has multiple boosting libraries. Differences include the choice of basic classification functions and combination rules.
  - gbm - boosting with trees.
  - mboost - model based boosting
  - ada - statistical boosting based on additive logistic regression
  - gamBoost for boosting generalized additive models
- Most of these are available in the caret package

Wage example

```r
library(ISLR); data(Wage); library(ggplot2); library(caret);
Wage <- subset(Wage,select=-c(logwage))
inTrain <- createDataPartition(y=Wage$wage,
                              p=0.7, list=FALSE)
training <- Wage[inTrain,]; testing <- Wage[-inTrain,]
```

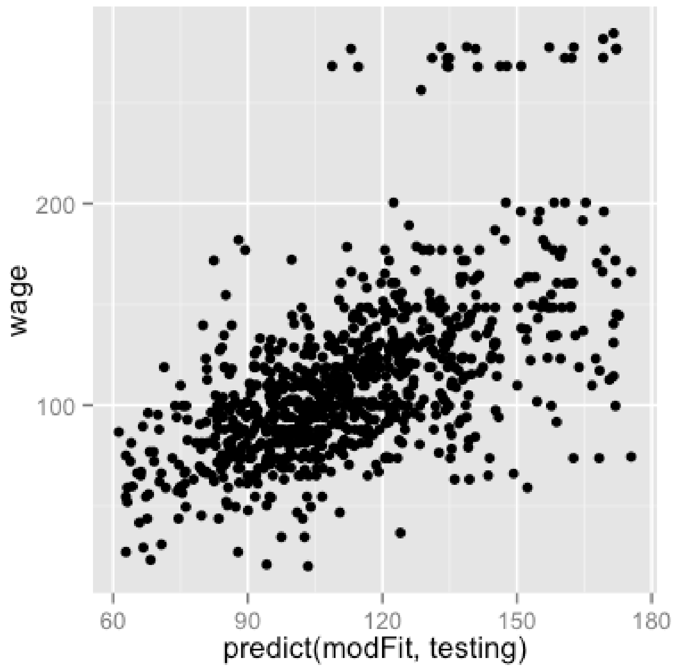
Fit the model

```r
modFit <- train(wage ~ ., method="gbm",data=training,verbose=FALSE)
print(modFit)
```

```
2102 samples
  10 predictors

No pre-processing
Resampling: Bootstrap (25 reps)

Summary of sample sizes: 2102, 2102, 2102, 2102, 2102, 2102, ...

Resampling results across tuning parameters:

  interaction.depth  n.trees  RMSE  Rsquared  RMSE SD  Rsquared SD
  1                  50       30    0.3       1        0.02
  1                  100      30    0.3       1        0.02
  1                  200      30    0.3       1        0.02
  2                  50       30    0.3       1        0.02
  2                  100      30    0.3       1        0.02
  2                  200      30    0.3       1        0.02
  3                  50       30    0.3       1        0.02
  3                  100      30    0.3       1        0.02
  3                  200      30    0.3       1        0.02
```

Plot the results

```
qplot(predict(modFit,testing),wage,data=testing)
```



Notes and further reading

- A couple of nice tutorials for boosting
  - Freund and Shapire - http://www.cc.gatech.edu/~thad/6601-gradAI-fall2013/boosting.pdf
  - Ron Meir- http://webee.technion.ac.il/people/rmeir/BoostingTutorial.pdf
- Boosting, random forests, and model ensembling are the most common tools that win Kaggle and other prediction contests.
  - http://www.netflixprize.com/assets/GrandPrize2009_BPC_BigChaos.pdf
  - https://kaggle2.blob.core.windows.net/wiki-files/327/09ccf652-8c1c-4a3d-b979-ce2369c985e4/Willem%20Mestrom%20-%20Milestone%201%20Description%20V2%202.pdf