RF + RLSC

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RF + RLSC

- Random Forests (RF) for feature selection
- Regularized Least Squares Classifiers (RLSC)
- Stochastic ensembles of RLSCs

Why Random Forests for Feature Selection?

- Basic idea: Train a classifier, then extract features that are important to the classifier
- Features are not chosen in isolation!
- RF is extremely fast to train
- Allows for mixed data types, missing values

Random Forests for Feature Selection - How?

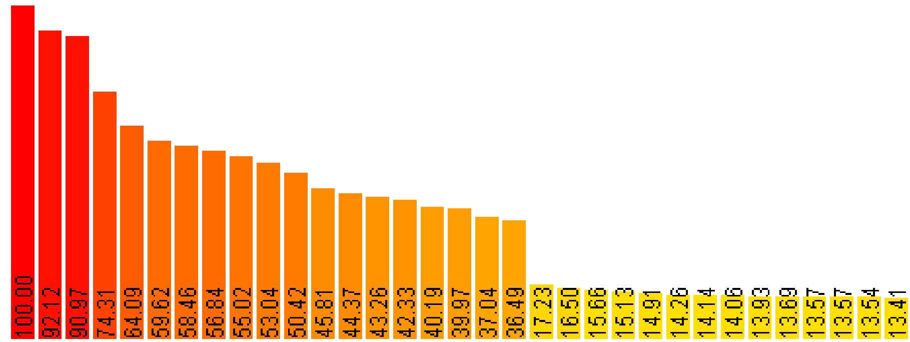
- **RF**
  - Trains a large forest of decision trees
  - Samples the training data for each tree
  - Samples the features to make each split
  - Error estimation from out-of-bag cases
  - Proximity measures, importance measures, …

- **An Importance Measure**
  - A split in a tree by using a particular variable results in a decrease of the gini index
  - Sum of these decreases over the forest ranks features by importance

Challenge Examples

<u>Madelon</u>

- **500 variables, training set has 2000 cases**
- **Constructed 500 trees**
- **Variable importance has a clear cut-off point at 19 variables**



- **Validation set: 600 cases**
- **The top 19 variables are the same, but the cut-off point is not that clear**

<u>Dexter</u>

- **20000 variables, 300 cases in both the training and the validation sets**
- **Top 50 variables from both sets are 70% shared (stability)**

Why Ensembles of RLSCs as Classifiers?

- **Why not just use RF? – The base learner is not good enough!**
- **RLSC solves a simple linear problem**

Given data $(x_i, y_i)_{i=1}^m$, find $f : X \to Y$ that generalizes:

1. Choose a kernel, such as $K(x, x') = e^{-\frac{||x-x'||^2}{2\sigma^2}}$,
2. $f(x) = \sum_{i=1}^m c_i K_{x_i}(x)$, where c_i is a solution to $(m\gamma\mathbf{I} + \mathbf{K})\mathbf{c} = \mathbf{y}$

- **Square loss function works well in binary classification (Poggio, Smale, et al.)**
- **Use minimum regularization (just to guarantee solution) to reduce bias, sample cases to produce diversity in base learners**

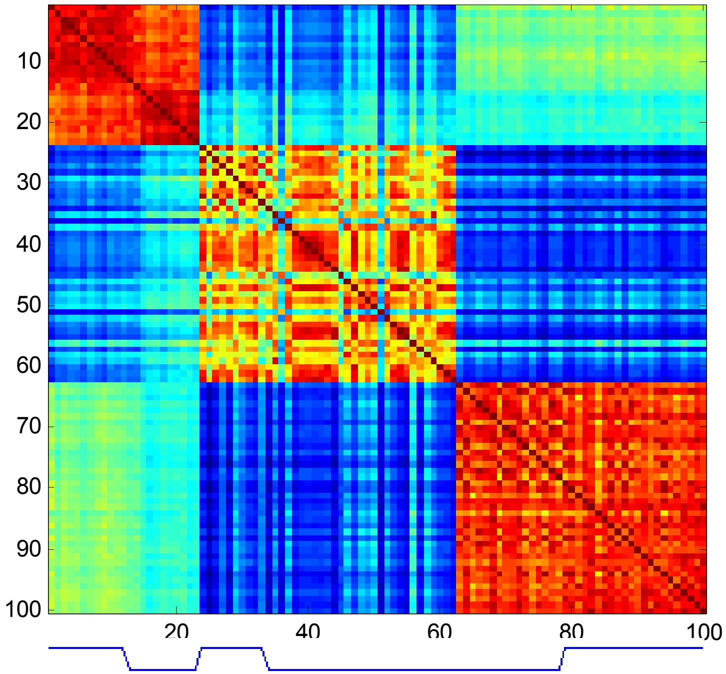
Things to worry about with RLSC Ensembles

- Kernel and its parameters?
- How many classifiers in the ensemble?
- What fraction of data to use to train each?
- How much to regularize (if at all)?
- Determine all of the above by cross-validation

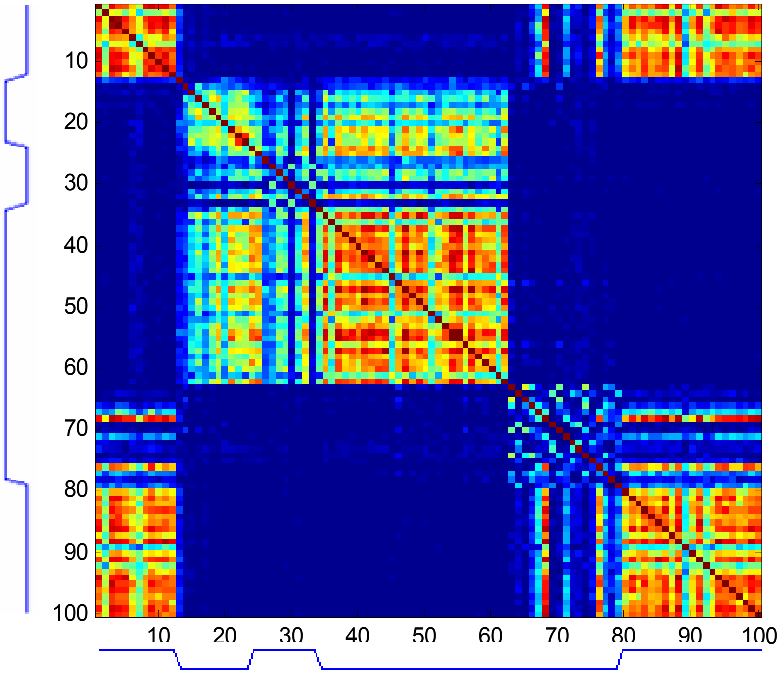
Future Directions

- RF as one type of supervised kernel generator using the pairwise similarities
- Similarity between 2 cases could be defined (for a single tree) as total number of common parent nodes, normalized by level of the deepest case, and summed up for the ensemble
- Minimum number of common parents to define nonzero similarity is another parameter acting like width in Gaussian kernels.
- Works for any type of data (numeric, categorical, mixed, missing values)!
- Feature selection bypassed altogether!

Arcene: Gaussian kernel



Arcene: Supervised kernel



Conclusion

- RF: Fast and robust feature selection
- RLSC: linear problem-solving
- Supervised kernels
- What we don't know…