Improve Prediction Accuracy for Clinic Medical Data Analysis

Master Graduate Project

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Outline

- Introduction
- Evaluation of state of art
- High Accurate Decision Tree Pruning & Ensembling Algorithm
  - Decision Tree
  - Pruning Method
  - Ensembling Method
- Result and Evaluation
- Conclusion

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Introduction

- Clinic medical data:
  - From practical clinic experiments and treatments
  - Valuable on symptoms description
  - One of major sources to diagnose and develop treatment
  - Costful and difficult to obtain

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Data Analysis on Clinic Medial Data

- Help to understand and detect medial diseases symptoms
- Drive new medical discovery
- Cut down on fraud and abuse
- Reduce medical treatment research and development cost
- Improve patient outcome

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Challenges on Clinical Medical Data Analysis

- Limited medical data size
- Complicated and redundant medical data features
- High noises
- Unbalanced disease classes
  - Most are healthy or usual classes
  - Small particle but much more meaningful diseases or unusual classes
- High requirement on accuracy

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Contributions

- Propose a high accurate clinic medical data classifier algorithm
  - Based on decision tree classification
  - Improved with pruning and ensembling algorithm
  - Presenting significantly higher accuracy than existing classification algorithms
- Implement and evaluate my algorithm on a Psoriasis clinic medical dataset
  - The results show our algorithm overwhelms other existing classification algorithms
  - A list of important features in Psoriasis dataset
- Our algorithm can be implemented on other clinic medical dataset

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Psoriasis Clinic Medical Dataset

- Psoriasis is an immune-mediated disease that causes raised, red, scaly patches to appear on the skin
  - Different types of Psoriasis need different treatments.
    - The type of Psoriasis cannot be determined accurately.
  - No standard methods for Psoriasis detection and lacking accuracy of diagnose.
  - Most patients with severe Psoriasis suffer a long time and have no sufficient treatments
- Dataset: 606 patients carrying Psoriasis from a hospital
  - 89 features of specific physical examinations
  - 5 classes representing Psoriasis types
  - Different data type of 89 features
    - Integer, String, float,
    - Unformatted with a lot of typos and unrecognized characters

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Evaluation on Existing Classification Algorithms

- Most of existing classification algorithms present low classification accuracy
  - <90%
- Decision tree and Decision tree based algorithms show higher accuracy
  - DT, RT and RT with cross validation
  - >84%

Naïve Bayesian(NB)	K Nearest Neighbors(KNN)	Decision tree(DT)	DT with **PCA**	Support Vector Machine(SVM)	SVM with **AdaBoost Classifier**	Random Forest(RF) with **CCA**	RF with **GridSearch CrossValidation**
	K = 5	Cart	n_components = 9		n_estimators = 100	Max_feature =9	Max_feature =9
AccuracyScore = 0.81	Accuracyscore=0.79	Accuracyscore = 0.84	Accuracyscore = 0.86	Accuracyscore = 0.81	Accuracyscore = 0.86	Accuracyscore = 0.87	Accuracyscore = 0.89

High Accurate Decision Tree Pruning & Ensemble (HADPE) Algorithm

- A Decision Tree based high accuracy algorithm
  - Understandable classification rules and outputs
    - Find the influencing features through tree structure
    - Significant for doctors and patient to understand the causes and symptoms
  - Higher accuracy compared to other algorithms
  - Easy to implement and high running efficiency

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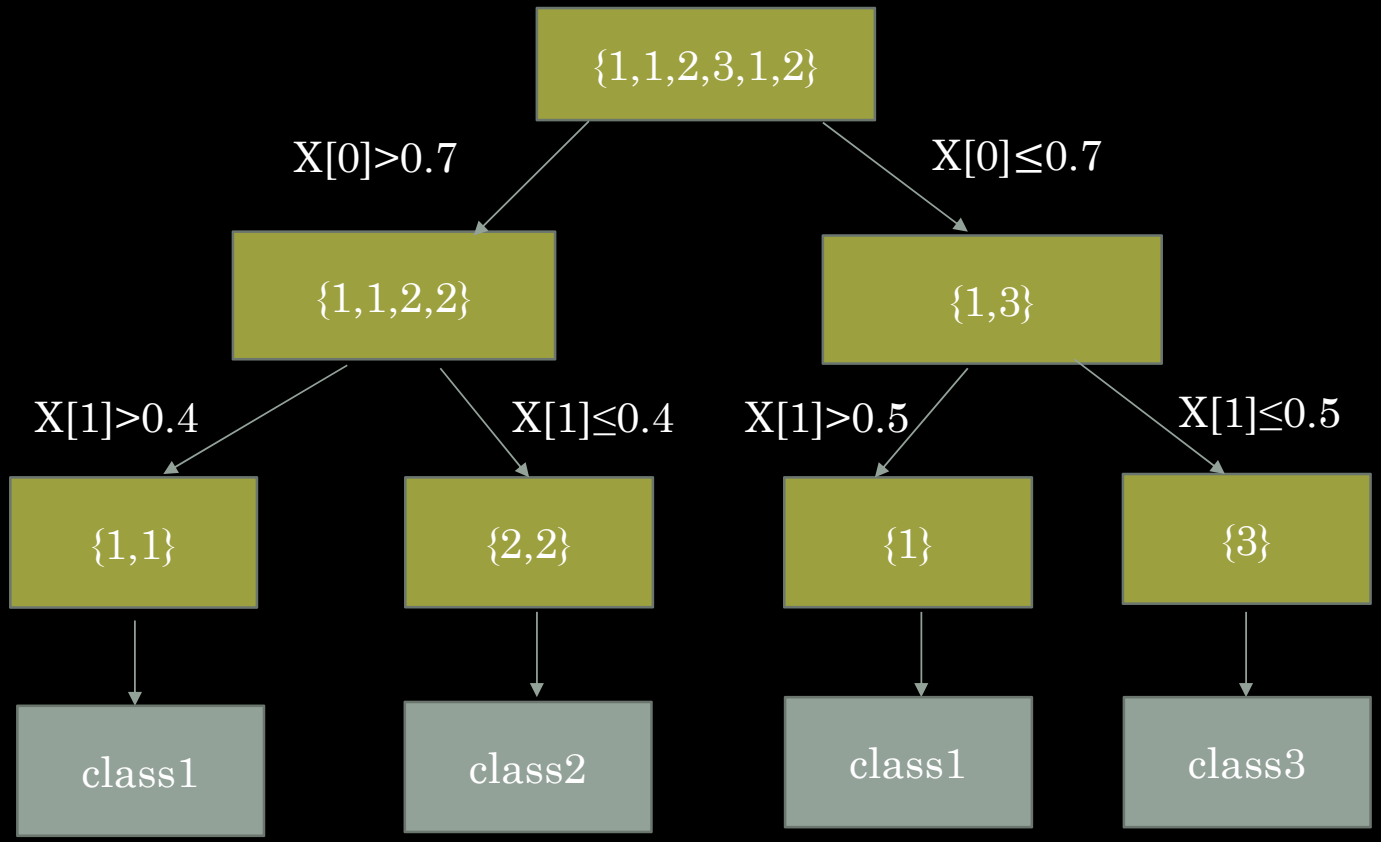
Decision Tree

- Tree is constructed in a top-down recursive divide-and-conquer manner
  - At start, all the training samples are at the root
  - Features are categorical (if continuous-valued, they are discretized)
  - Samples are split recursively based on selected features
  - Features are selected on the basis of a heuristic or statistical measure (e.g., information impurity)
  - Stop when
    - All samples belongs to same class
    - Or no remaining features for further splitting
- Predict by finding a path to leaf node that matches the values of features

Decision Tree Example

Three Classes Two Features



Decision Tree Feature Selection

- Used in CART (introduced by Leo Breiman)
- Split tree node to achieve lowest impurity after splitting
  - Impurity measured by Gini index:
    - $Gini(S) = 1 - \sum_{i \in S} p_i^2$
      - p_i : probability of class i in set S
    - **Higher Gini index ,higher impurity**
- Efficient to split continuous values
- More reliable compared to other criteria

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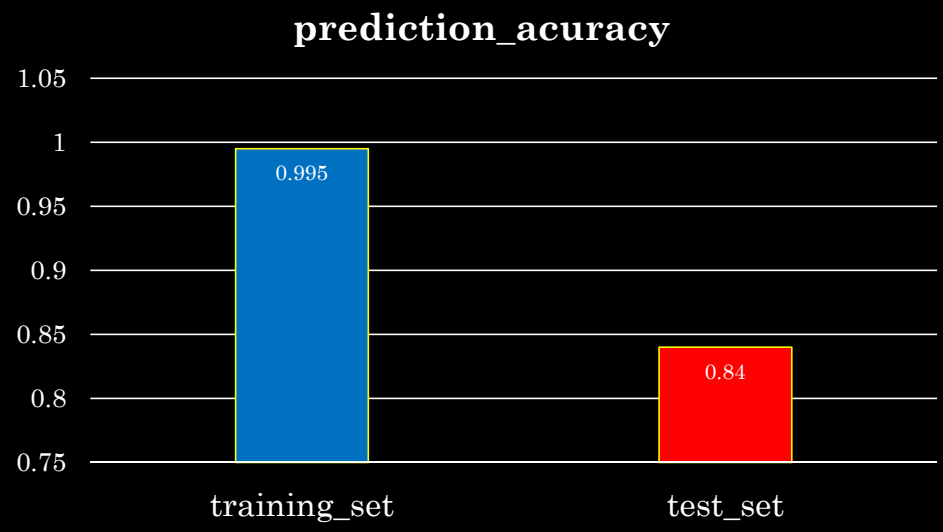
Problems in Decision Tree

- Overfitting: selection of an attribute that is non-optimal for prediction
- Fragmentation: data are fragmented into (too) many small sets
- Caused by:
  - Trying to fit noise
  - Lack of identical features



Prediction accuracy comparison on training set and test set

Pruning: Solve Overfitting in DT

- Remove sections of tree that provide little power to classify observations
  - Set criteria when splitting tree node to subtree nodes
  - Stop splitting tree node when criteria is not satisfied
  - Common criteria:
    - Maximum number of leaf nodes
    - Maximum number of tree layers
    - Minimum impurity

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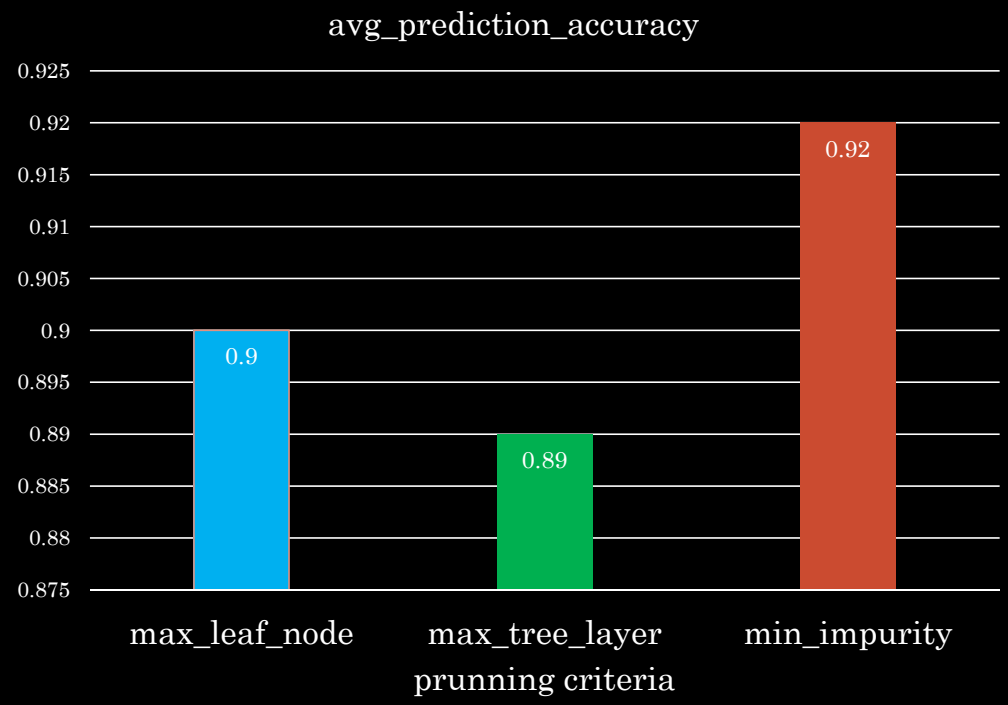
Pruning: Solve Overfitting in DT

- HADPE uses pruning with **minimum impurity** criteria for splitting
  - Only split a tree node if this tree node has impurity larger than minimum impurity



Decision Tree Ensemble Method

- Bagging a strong classifier from a list of weak/sub classifiers
  - Build a list of sub classifiers from ***random*** training sets
    - Each sub classifier built by a distinct pruning criteria (min_impurity value)
  - Validate each sub classifier by a validation set
    - Increase the weights the sub classifiers that
      correctly predict the class of the samples in validation set
    - Decrease otherwise
    - To detect and set higher weight to the sub classifiers that
      - Have better pruning criteria
      - Have higher prediction accuracy

$$\omega_{i(j+1)} = \begin{cases} \omega_{ij} * e^{\alpha} & : if\ classifier\ i\ predicts\ sample\ (j+1)\ correctly \\ \omega_{ij} * e^{-\alpha} & : \qquad otherwise \end{cases}$$

$$0 < \alpha < 1$$

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Decision Tree Ensemble Method

- Prediction:
  - After training, predictions for unseen samples(test_set) can be made by taking the majority vote in the case of decision trees.
- better model performance

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Results and Evaluation

- Implement based on Psoriasis clinic medial dataset
- Dataset is cleaned and preprocessed for missing data, unrecognized data, etc.
- Randomly select training set, validation set, testing set
  - 70% training set
  - 30% testing set
  - Validation set:[100, 200, 300]
- Five HADPE configurations on sub DT classifier size:
  - [10,15,20,25,30]
- Min_impurity criteria randomly chosen from [0,0.1]

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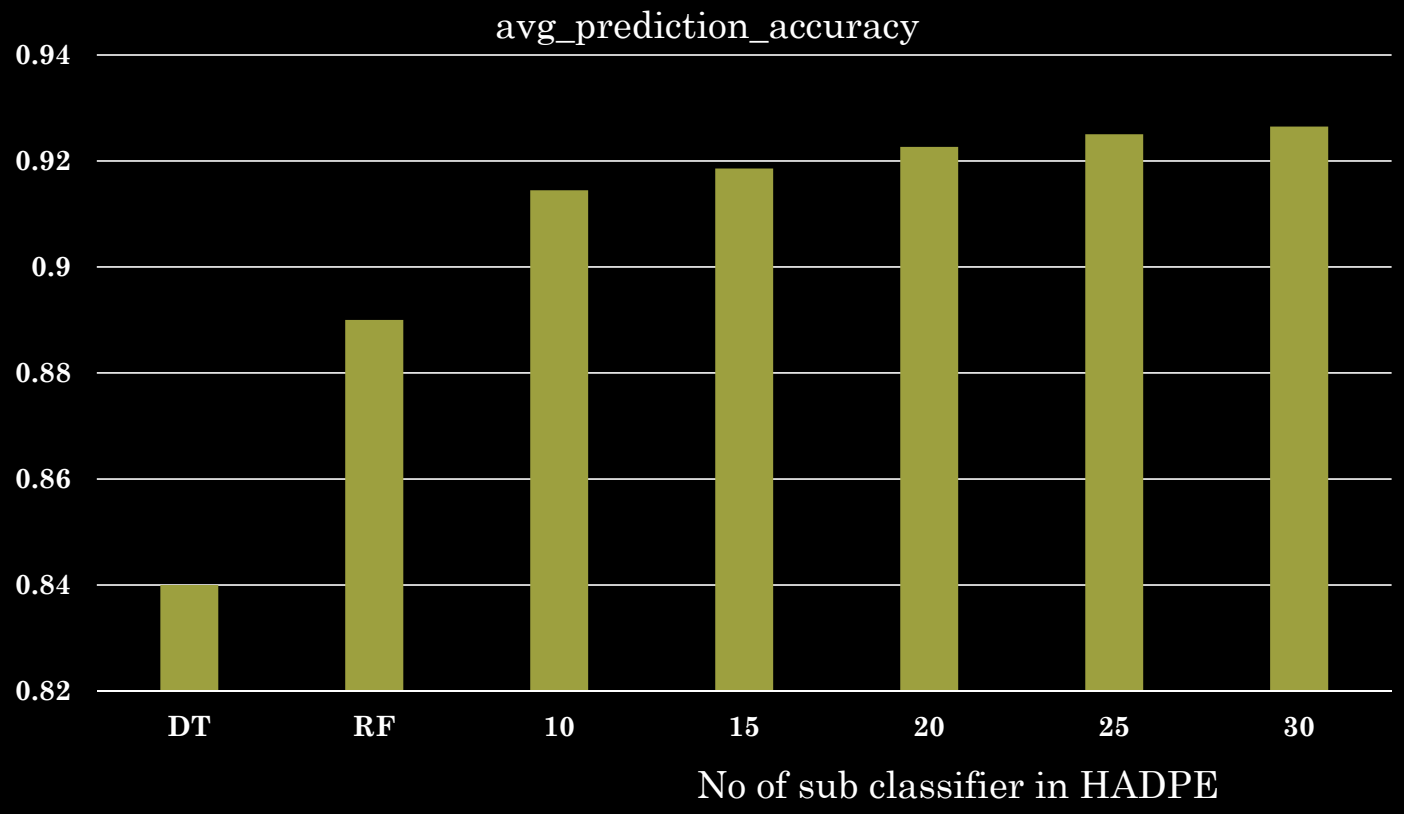
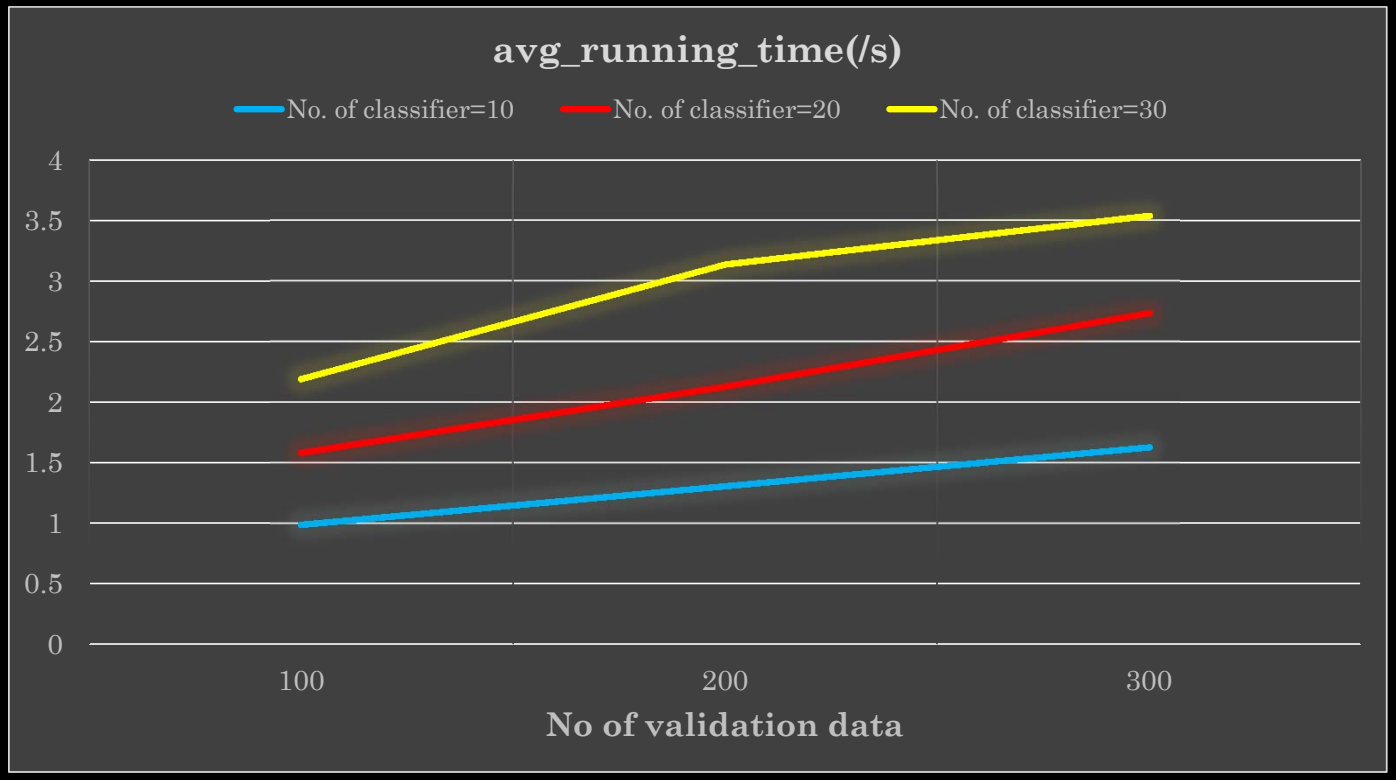
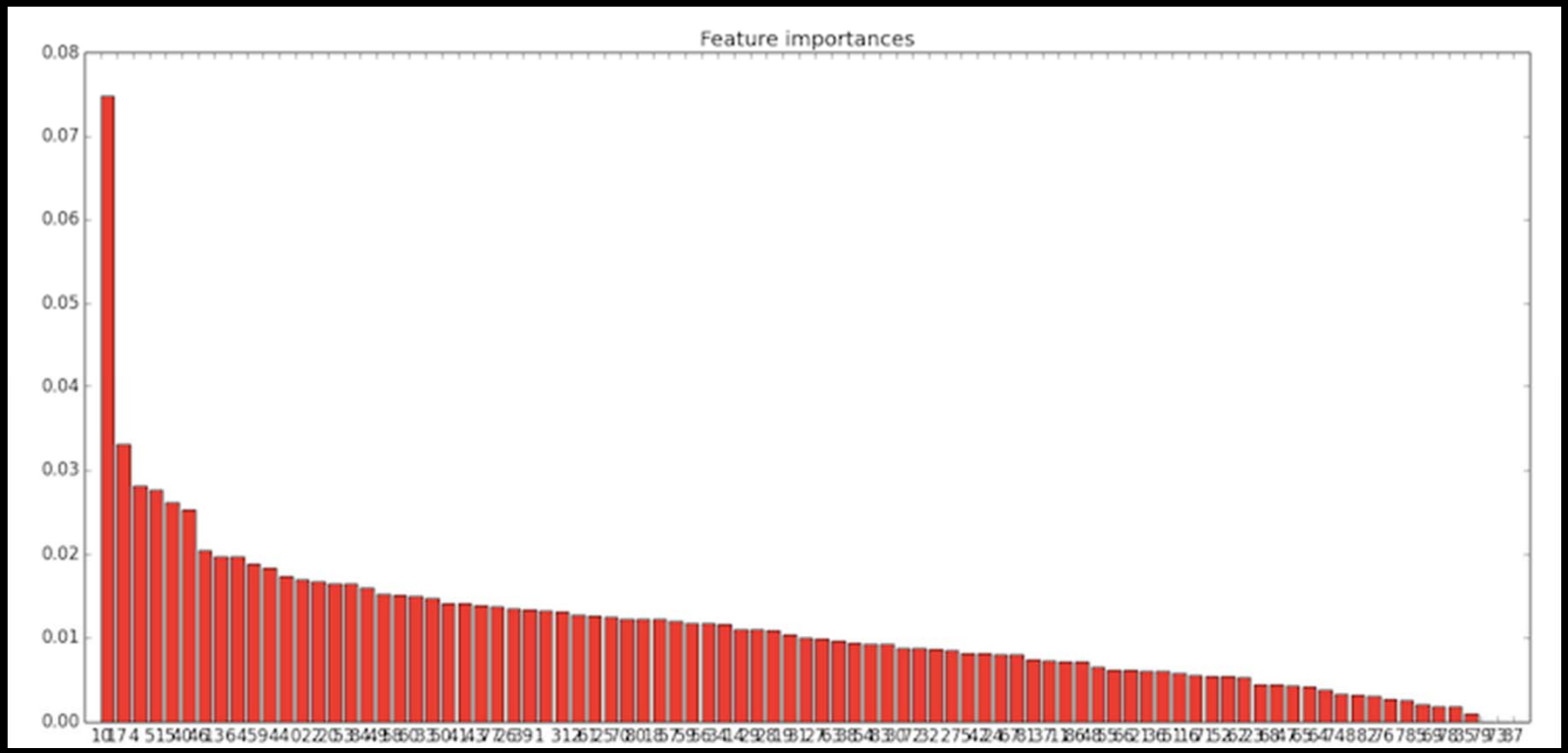
Prediction Accuracy



Running Time



Feature Importance



Feature Importance

- Most Six Important Features in construction the tree:
- Column 4: Low Pressure
- Column 3: High Pressure
- Column 5: White Blood
- Column 15: Basophil
- Column 17: Red Blood
- Column 40: Total Bilirubin

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Conclusion

- Investigate the problem of clinic medical data analysis
  - Meaning and challenges
- Evaluate existing classification algorithms
  - Lower accuracy on the medical data
- Propose our high accuracy classification algorithm
  - Hybrid pruning and ensembling
- Our evaluation shows our algorithm significantly overwhelms existing works
- The algorithm can be used on other clinical dataset

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Summary

- Not fitting algorithm:
  - Convolutional Neural Networks(CNN)
  - Deep Neural Networks(DNN)
  - Support Vector Machine
  - KNN
  - …
- Fitting algorithm:
  - Decision tree(DT), Random Forest(RF)
  - Ensemble Method(Boosting, Bagging)
- Clinical Data Management
  - Small Size -- Ask for as more data as possible
  - Missing value – Imputing method

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THANK YOU!

Q&A

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