iForest: Interpreting Random Forests via Visual Analytics

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Background

• Random Forest

Fraud Detection  Medical Diagnosis  Churn Prediction

Icons created by Anatolii Babii, Atif Arshad, and Dinosoft Labs from the Noun Project.
Background – Decision Tree

- Temp > 80°F
  - Wind > 1mph
    - Yes
    - No
  - Wind < 4.5mph
    - Yes
    - No
- Pressure > 25 inHg
  - Yes
  - No
- Pressure > 30 inHg
  - Yes
  - No
Background – Decision Tree

- Temp > 80°F
  - Yes
  - Wind > 1mph
  - Yes
    - Pressure > 25 inHg
      - Yes
      - Sun
      - No
      - Clouds
  - No
  - Wind < 4.5mph
    - Yes
    - Pressure > 30 inHg
      - Yes
      - Sun
      - No
      - Clouds
    - No

Background – Random Forest
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Motivation – Random Forest
Random Forests are A+ predictors on performance but rate an F on interpretability

L. Breiman “Statistical modeling: The two cultures.”
Interpretability

This is your machine learning system?

Yup! You pour the data into this big pile of linear algebra, then collect the answers on the other side.

What if the answers are wrong?

Just stir the pile until they start looking right.

Source: https://xkcd.com/1838/
Interpretability

- Reveal the relationships between features and predictions
- Uncover the underlying working mechanisms
- Provide case-based reasoning
iForest: Interpreting Random Forests via Visual Analytics
iForest - Visual Components

Data Overview

Feature View

Decision Path View
Demo
iForest – Data Overview

Provide case-based reasoning
iForest – Data Overview

• Methods: confusion matrix and t-sne projection
iForest – Data Overview

- Methods: confusion matrix and t-sne projection
Reveal the relationships between features and predictions
iForest – Feature View

• Methods: data distribution and partial dependence plot

Each cell illustrates the statistics and importance of a feature.
iForest – Feature View

• Methods: data distribution and partial dependence plot
iForest – Feature View

• Methods: data distribution and partial dependence plot
iForest – Feature View

• Methods: data distribution and partial dependence plot
iForest – Feature View

• Methods: data distribution and partial dependence plot
Uncover the underlying working mechanisms
iForest – Decision Path View

• Goal: audit the decision process of a particular data item
iForest – Decision Path View

• Decision Path Projection

Data id: 001 33 67 → ration between positive and negative decision paths

each circle represents a decision path

lasso to select a specific set of paths for exploration
iForest – Decision Path View

• Feature Summary

Feature Cell: Summarize the feature ranges of the selected paths

Pixel-based bar chart: feature range summary

Vertical bar: feature value of the current data item
iForest – Decision Path View

• Feature Summary

Decision Path I:

Layer 1 (root) → C > 1.5 → Layer 3

A < 0.5 → C > 1.5 → C < 3.5

Decision Path II:

Layer 2 → A < 0.5

C > 2.5 → A < 0.5

Feature Summary:

- A < 0.5
- C > 1.5
- C < 3.5
iForest – Decision Path View

• Feature Summary

Decision Path I:

Layer 1 (root)
A < 0.5

Layer 2
C > 1.5

Layer 3
C < 3.5

Decision Path II:

Layer 1 (root)
C > 2.5

Layer 2
A < 0.5
iForest – Decision Path View

• Feature Summary

Decision Path I:  
- **Layer 1 (root):** $A < 0.5$  
- **Layer 2:** $C > 1.5$  
- **Layer 3:** $C < 3.5$

Decision Path II:  
- **Layer 1 (root):** $C > 2.5$  
- **Layer 2:** $A < 0.5$
iForest – Decision Path View

• Feature Summary

- **Feature A**
  - Layer 1 (root): $A < 0.5$
  - Layer 2: $C > 1.5$
  - Layer 3: $C < 3.5$

- **Feature B**
  - No decision path shown

- **Feature C**
  - Layer 1 (root): $C > 2.5$
  - Layer 2: $A < 0.5$

- **Feature D**
  - No decision path shown
iForest – Decision Path View

• Decision Path Flow: layer-level feature ranges
Evaluation – Usage Scenario

• Two usage scenarios using the Titanic shipwreck and German Credit data

• Titanic shipwreck statistics:
  • 891 passengers and 6 features after pre-processing

• German Credit statistics:
  • 1,000 bank accounts and 9 features
Usage Scenario – Titanic
Evaluation – User Study

• Qualitative user study
  • 10 participants recruited from local university and an industry research lab
  • 10 tasks covering all important aspects in random forest interpretation
  • 12 questions related with iForest usage in a post-session interview

Task Completion Time (seconds)
Future Work

• Support other tree-based model such as boosting trees

• Support multi-class classification or regression

• Support random forest diagnosis and debug
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