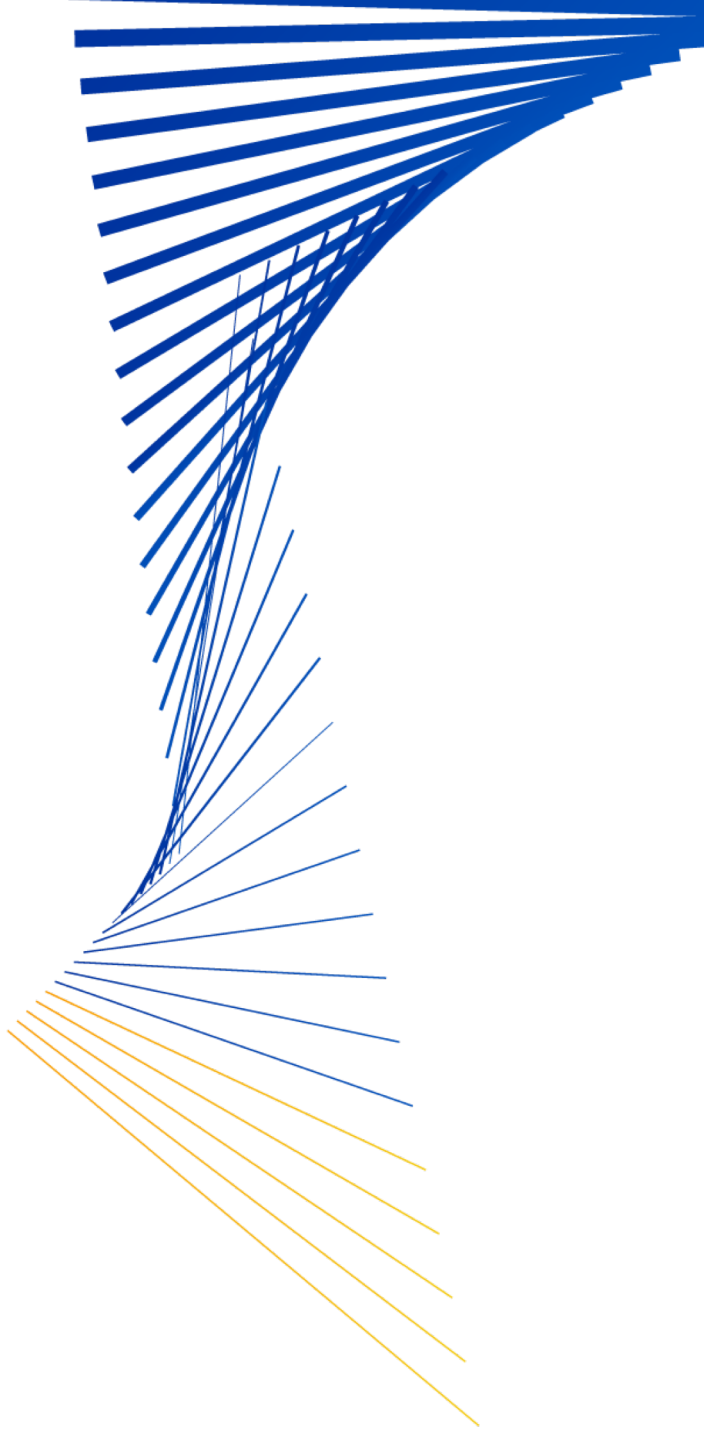
iForest: Interpreting Random Forests via Visual Analytics

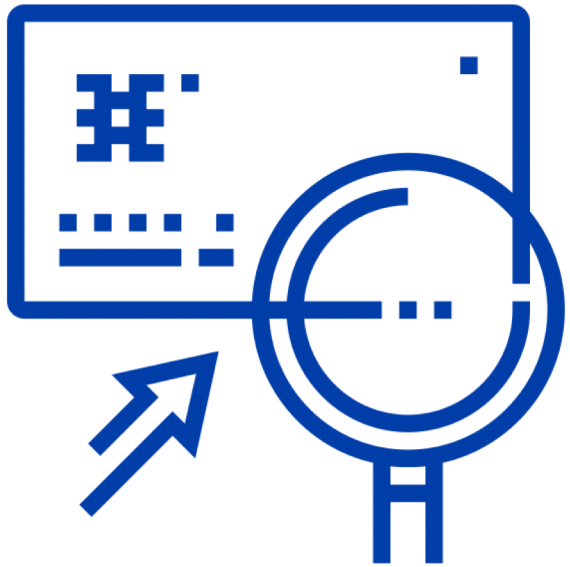
Xun Zhao, **Yanhong Wu**, Dik Lun Lee, Weiwei Cui



VISA
香港科技大學 THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY
Microsoft Research 微软亚洲研究院

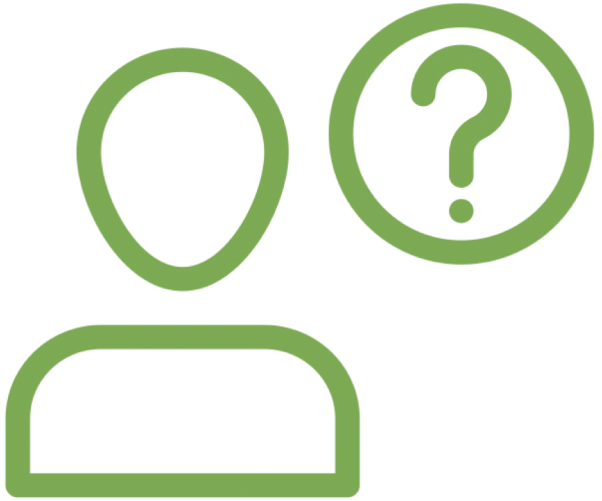
Background

- Random Forest



Fraud Detection

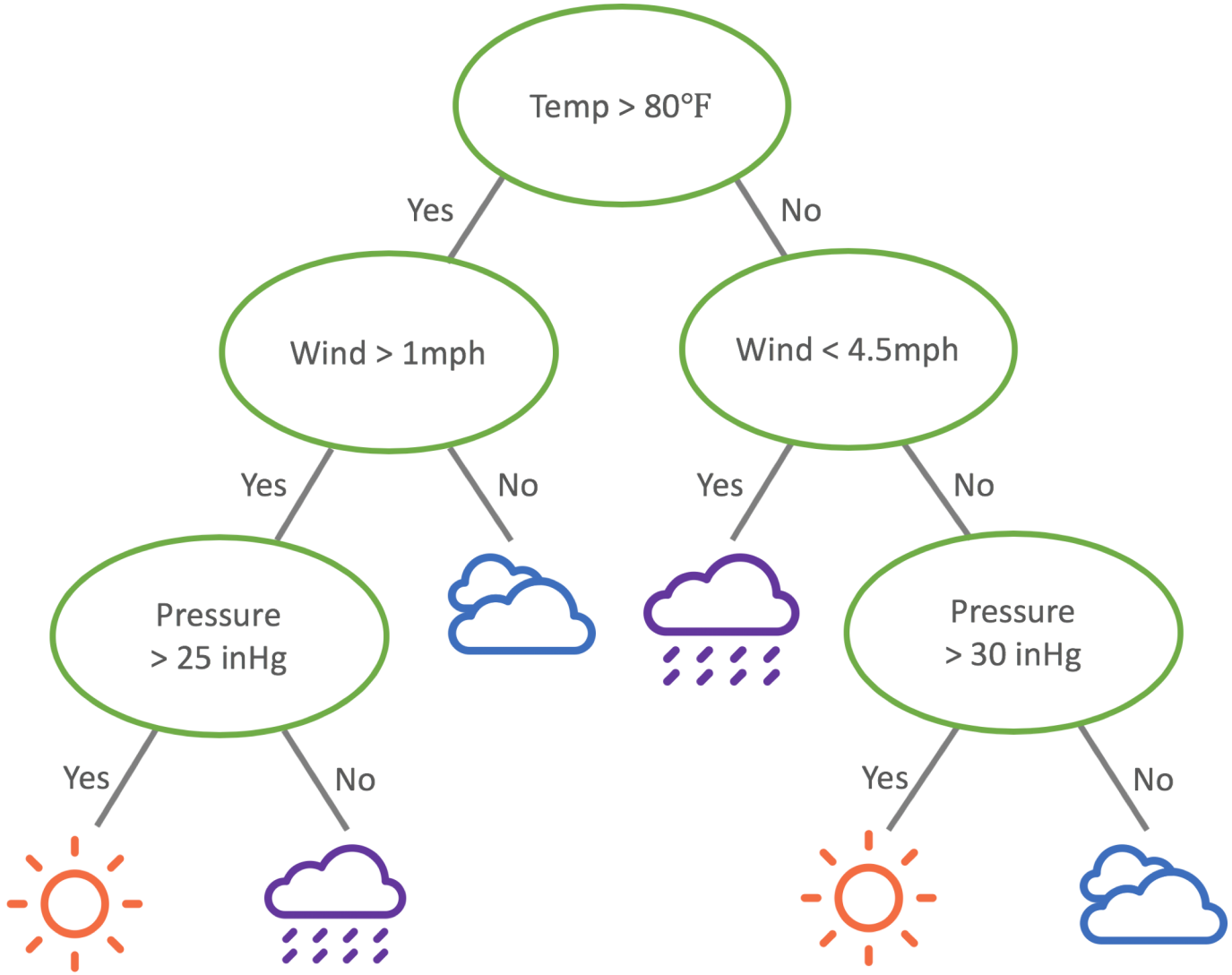
Medical Diagnosis



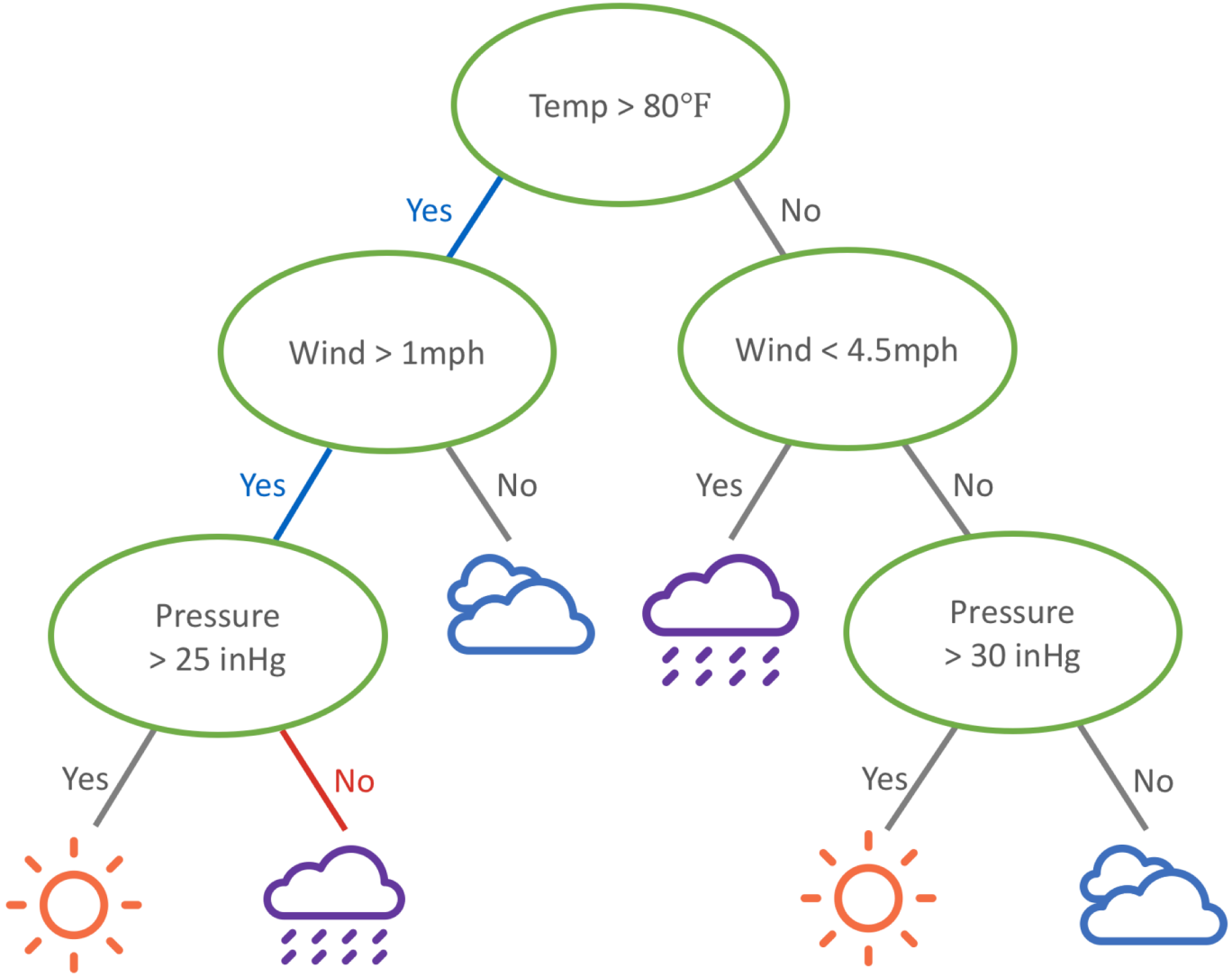
Churn Prediction

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

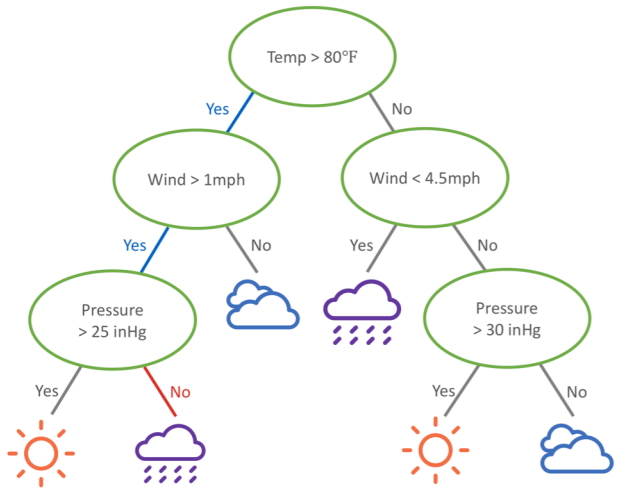
Background – Decision Tree

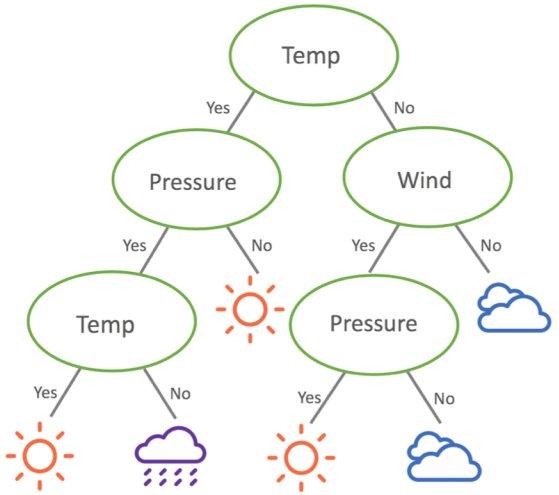


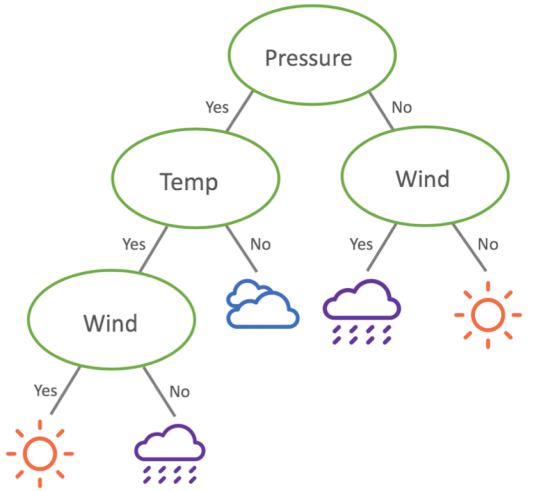
Background – Decision Tree

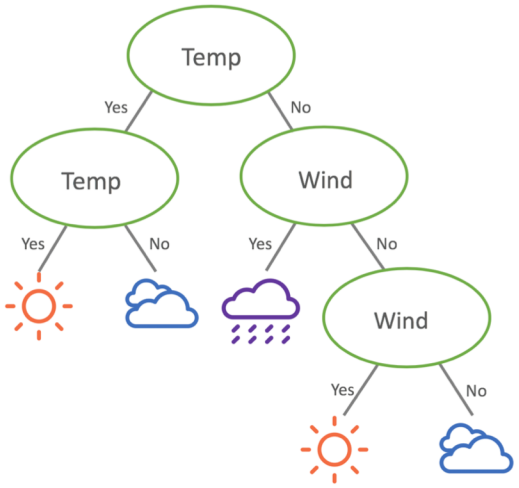


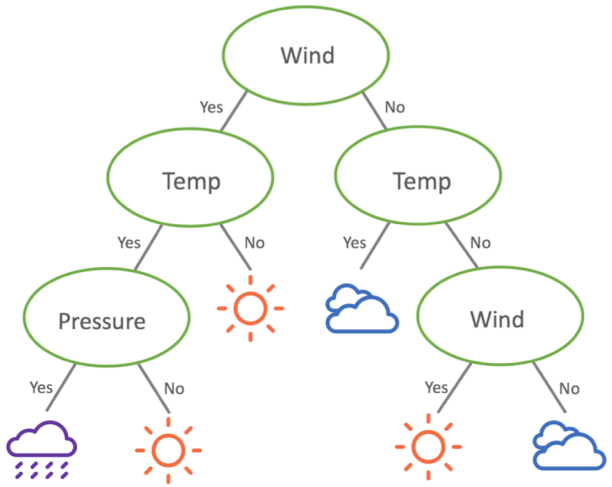
Background – Random Forest

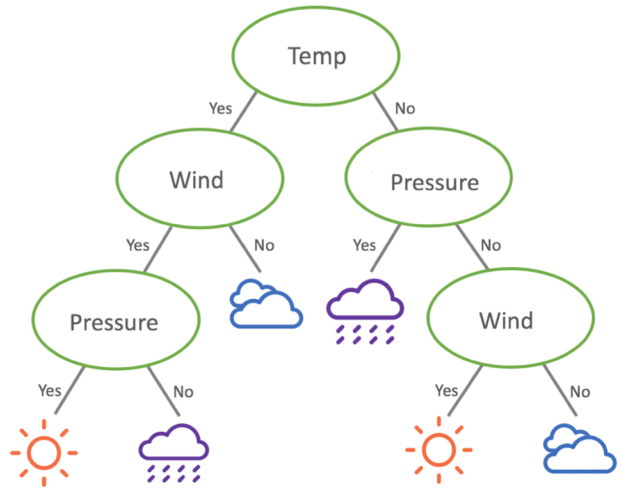




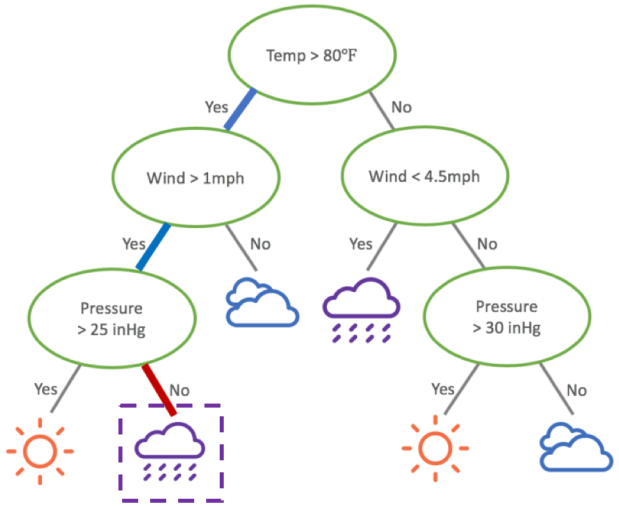


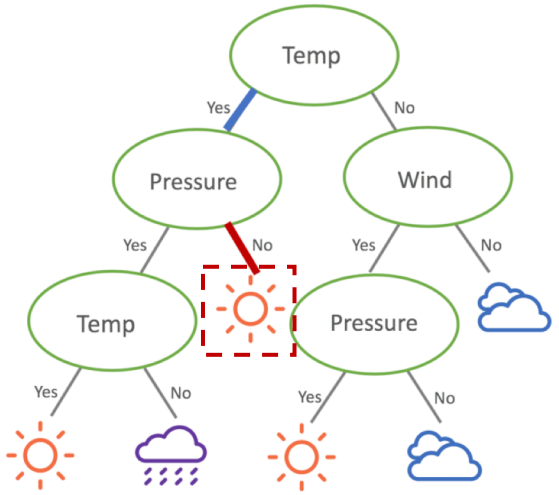


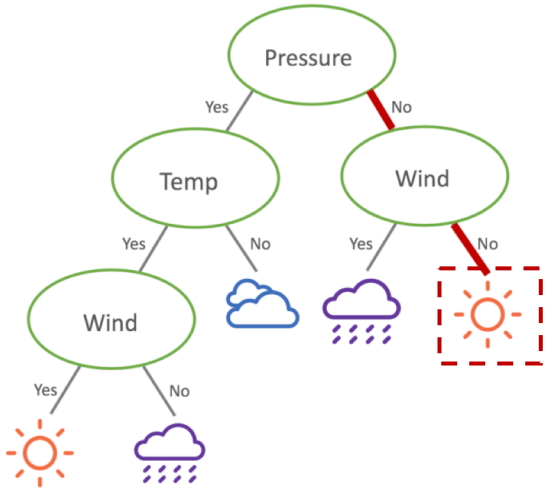


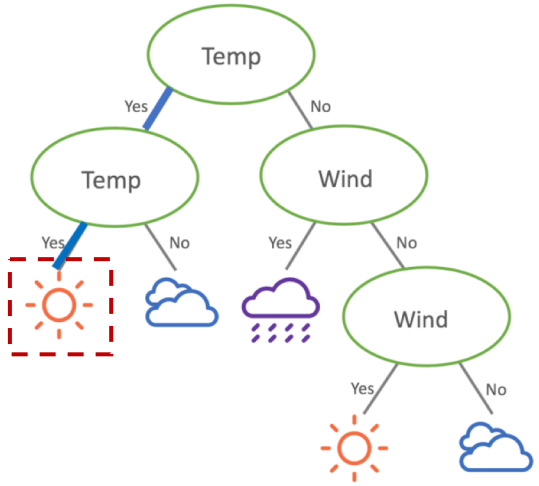


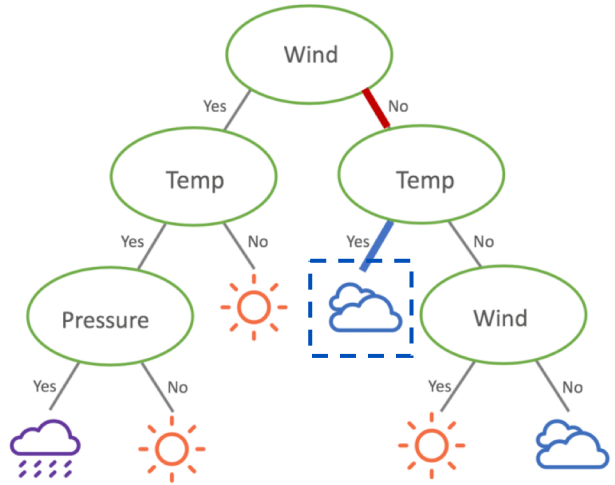
Background – Random Forest

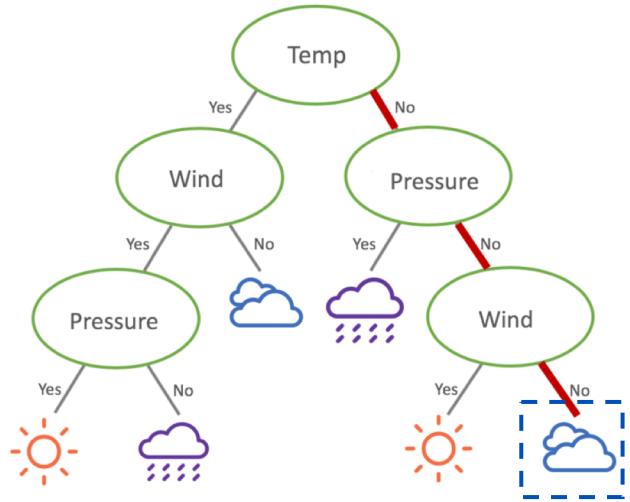




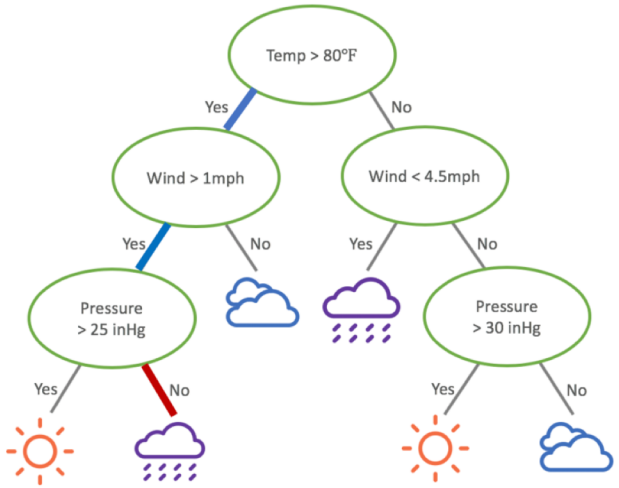


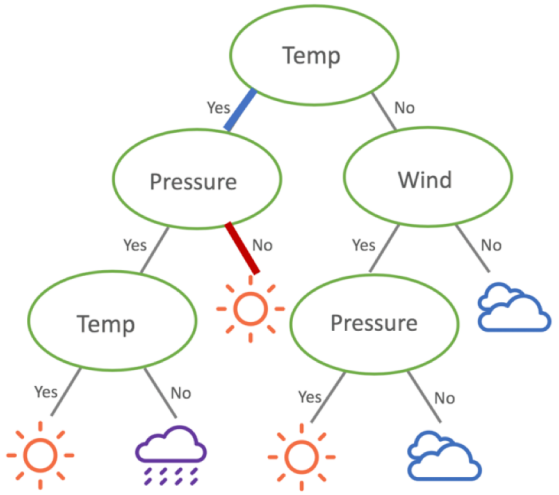


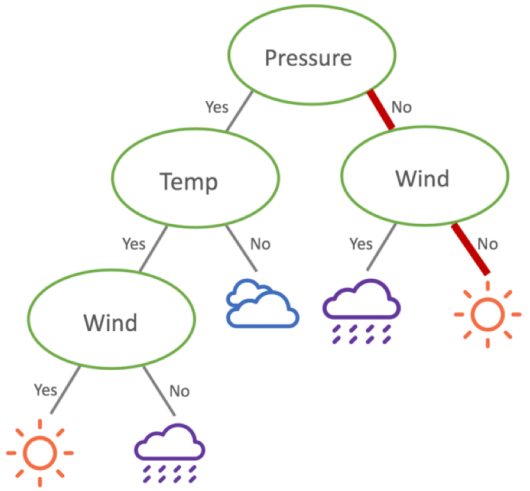


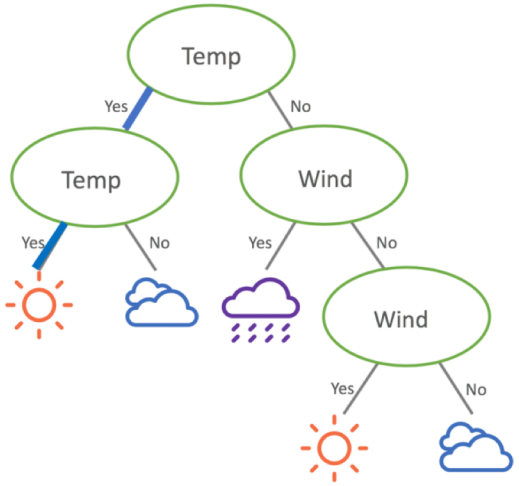


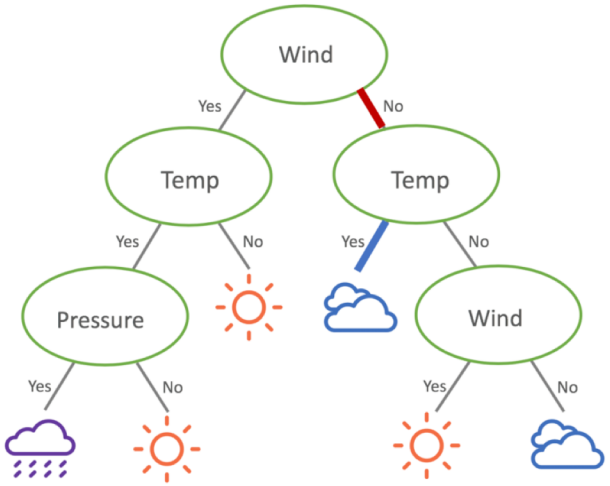
Background – Random Forest

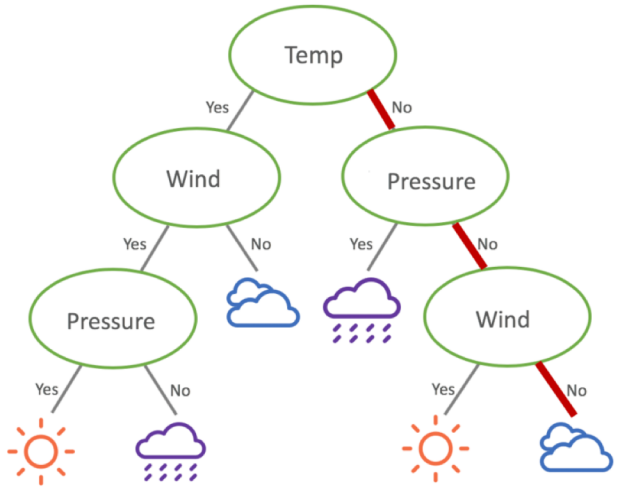












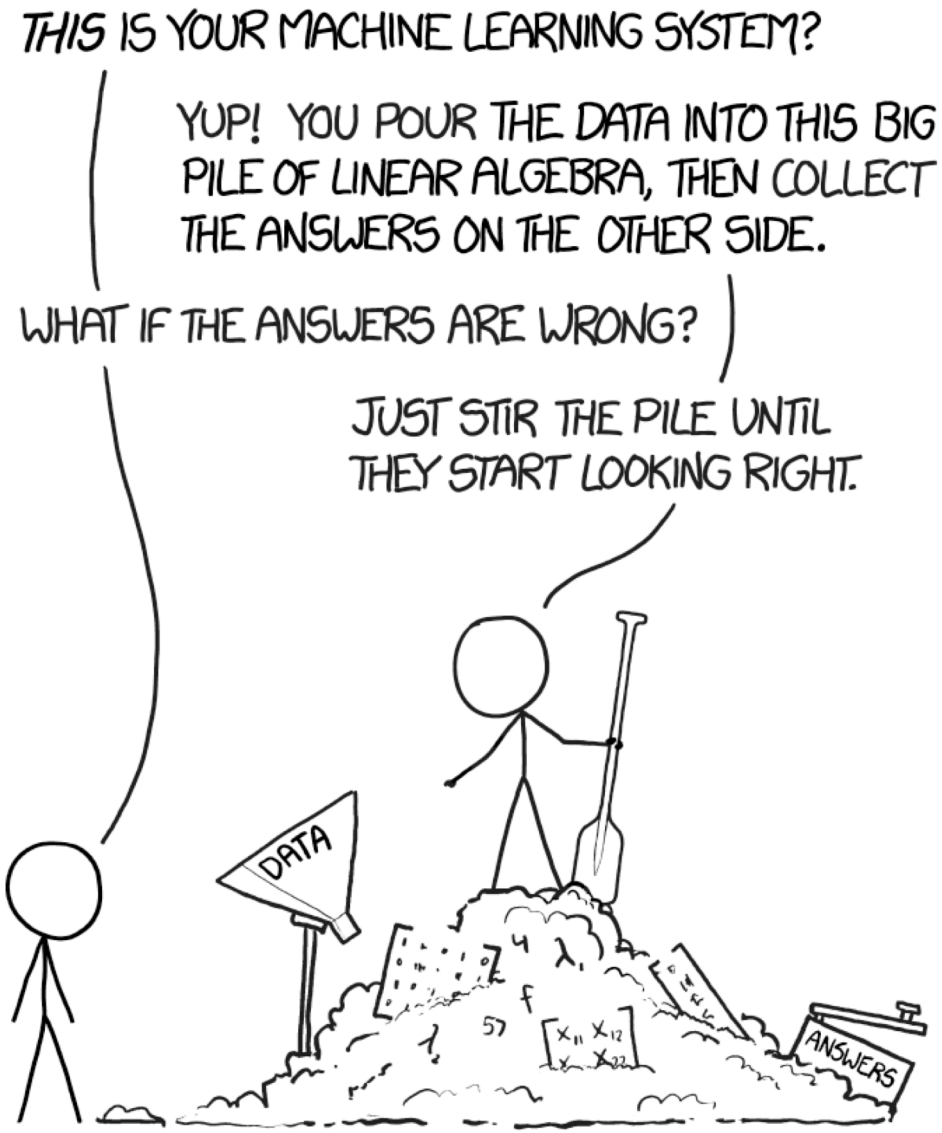
Motivation – Random Forest

“

Random Forests are A+ predictors on performance but rate an F on interpretability

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

Interpretability

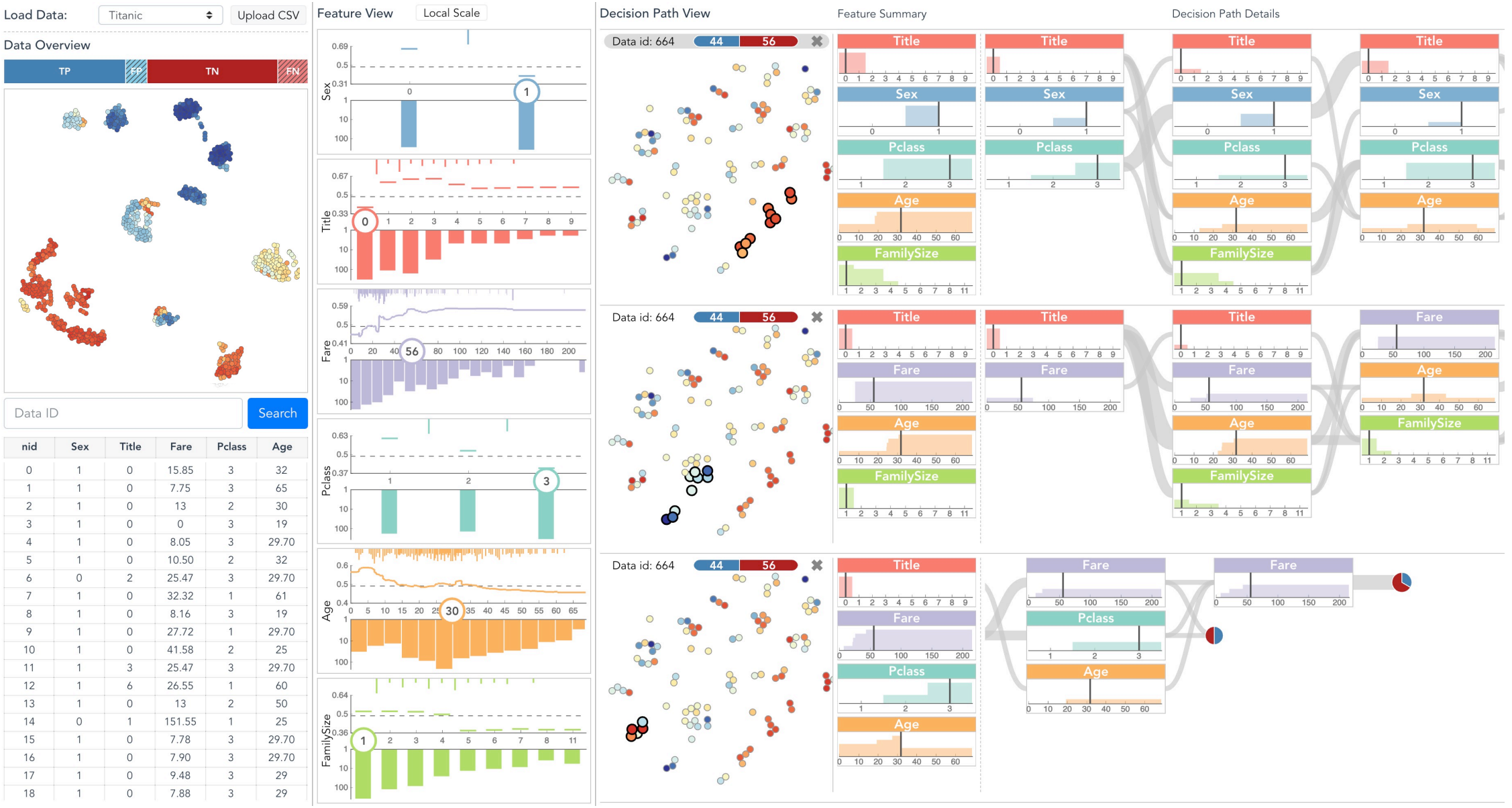


Source: https://xkcd.com/1838/

Interpretability

- Reveal the relationships between features and predictions
- Uncover the underlying working mechanisms
- Provide case-based reasoning

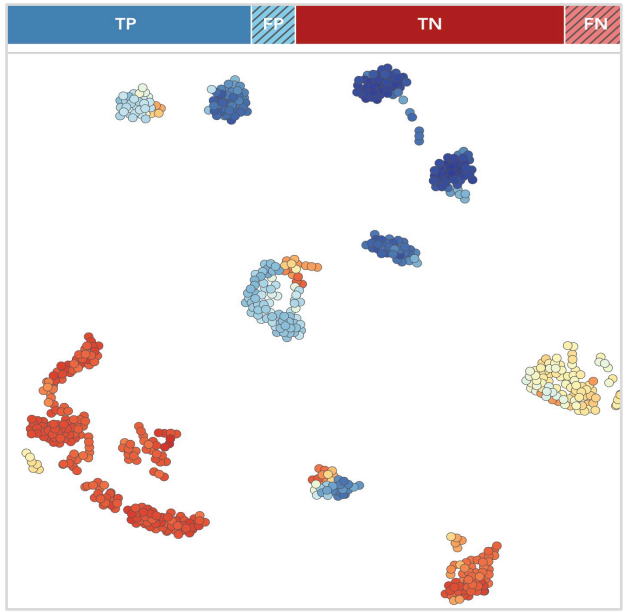
iForest: Interpreting Random Forests via Visual Analytics



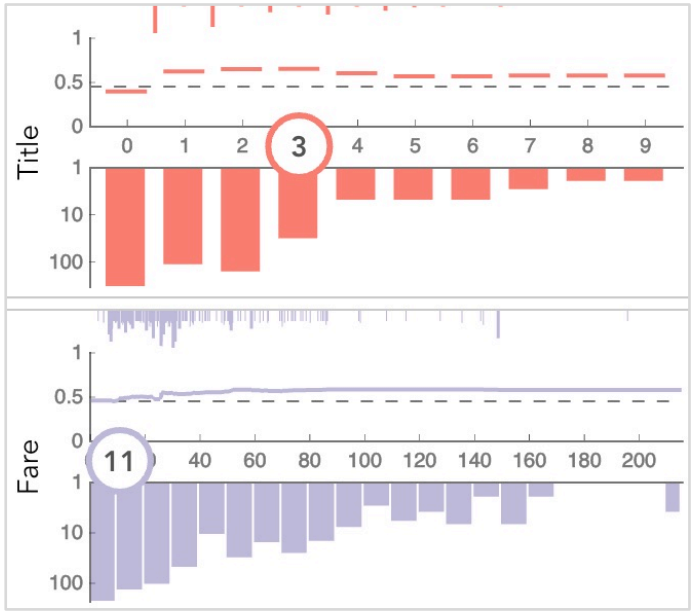
nid	Sex	Title	Fare	Pclass	Age
0	1	0	15.85	3	32
1	1	0	7.75	3	65
2	1	0	13	2	30
3	1	0	0	3	19
4	1	0	8.05	3	29.70
5	1	0	10.50	2	32
6	0	2	25.47	3	29.70
7	1	0	32.32	1	61
8	1	0	8.16	3	19
9	1	0	27.72	1	29.70
10	1	0	41.58	2	25
11	1	3	25.47	3	29.70
12	1	6	26.55	1	60
13	1	0	13	2	50
14	0	1	151.55	1	25
15	1	0	7.78	3	29.70
16	1	0	7.90	3	29.70
17	1	0	9.48	3	29
18	1	0	7.88	3	29

iForest - Visual Components

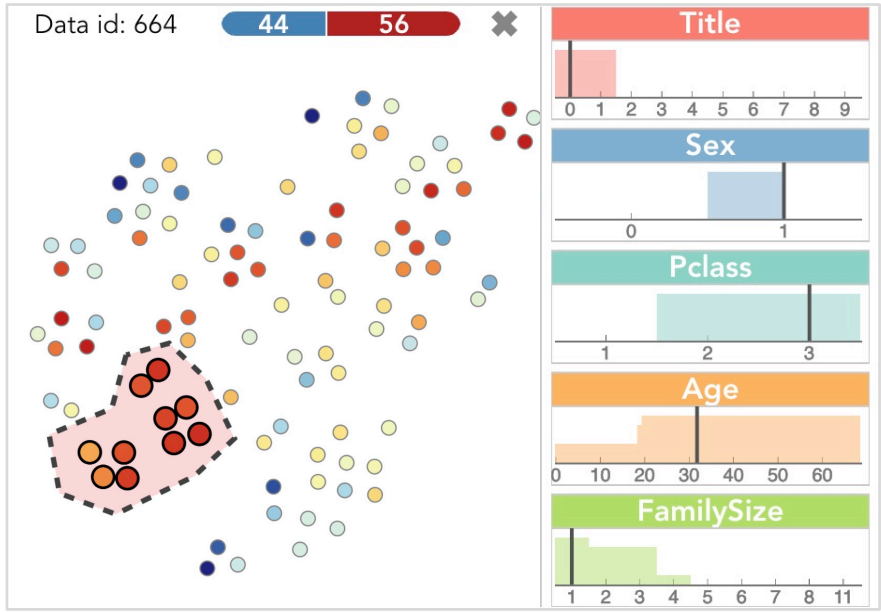
Data Overview



Feature View



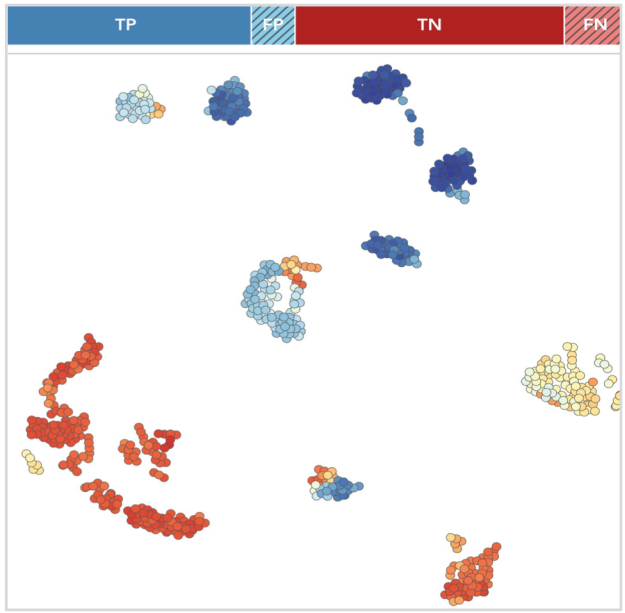
Decision Path View



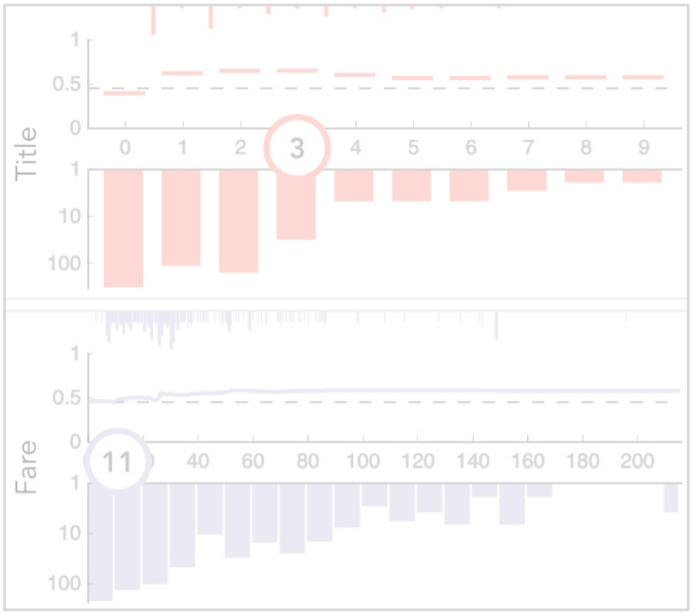
Demo

iForest – Data Overview

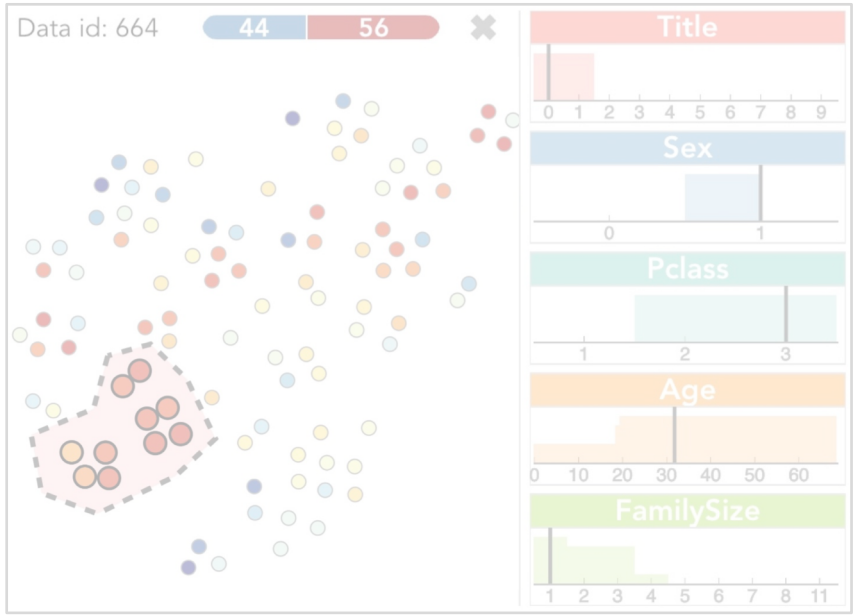
Data Overview



Feature View



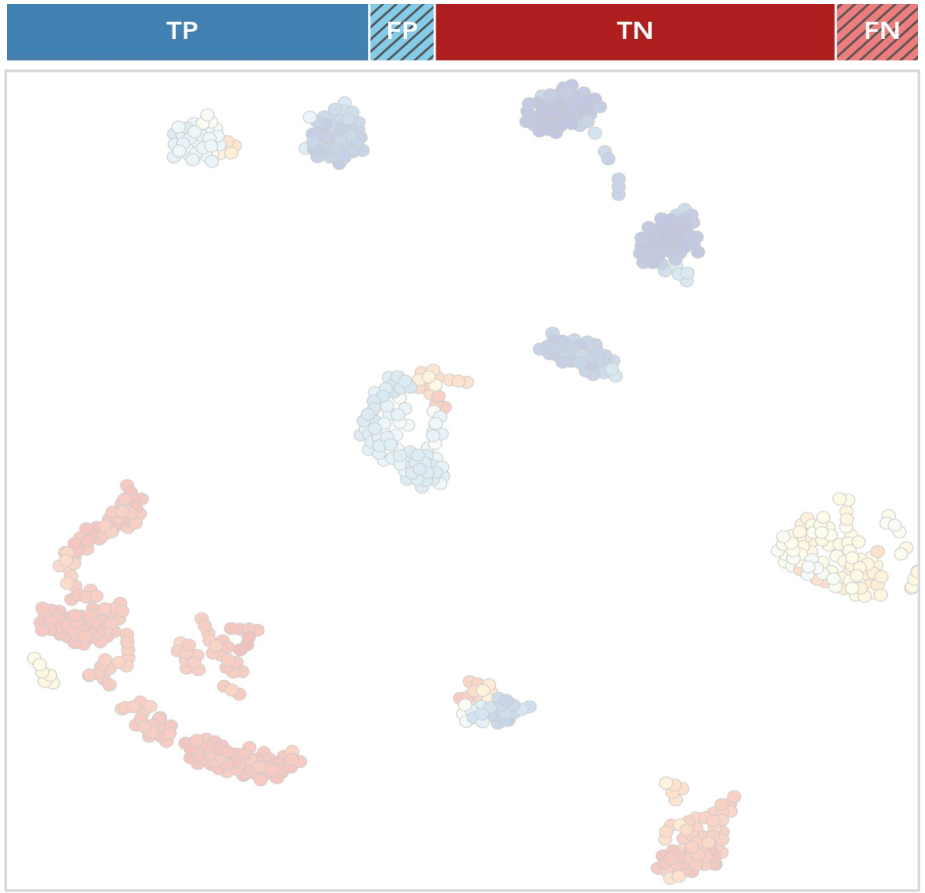
Decision Path View



- Provide case-based reasoning

iForest – Data Overview

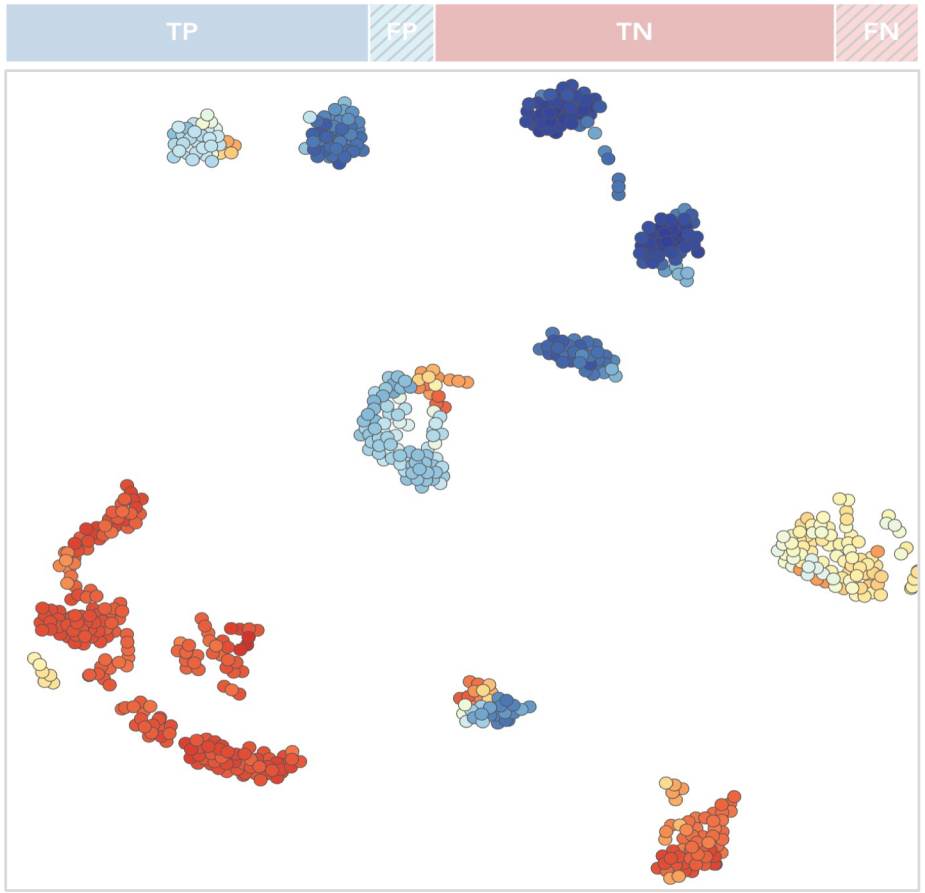
- Methods: confusion matrix and t-sne projection



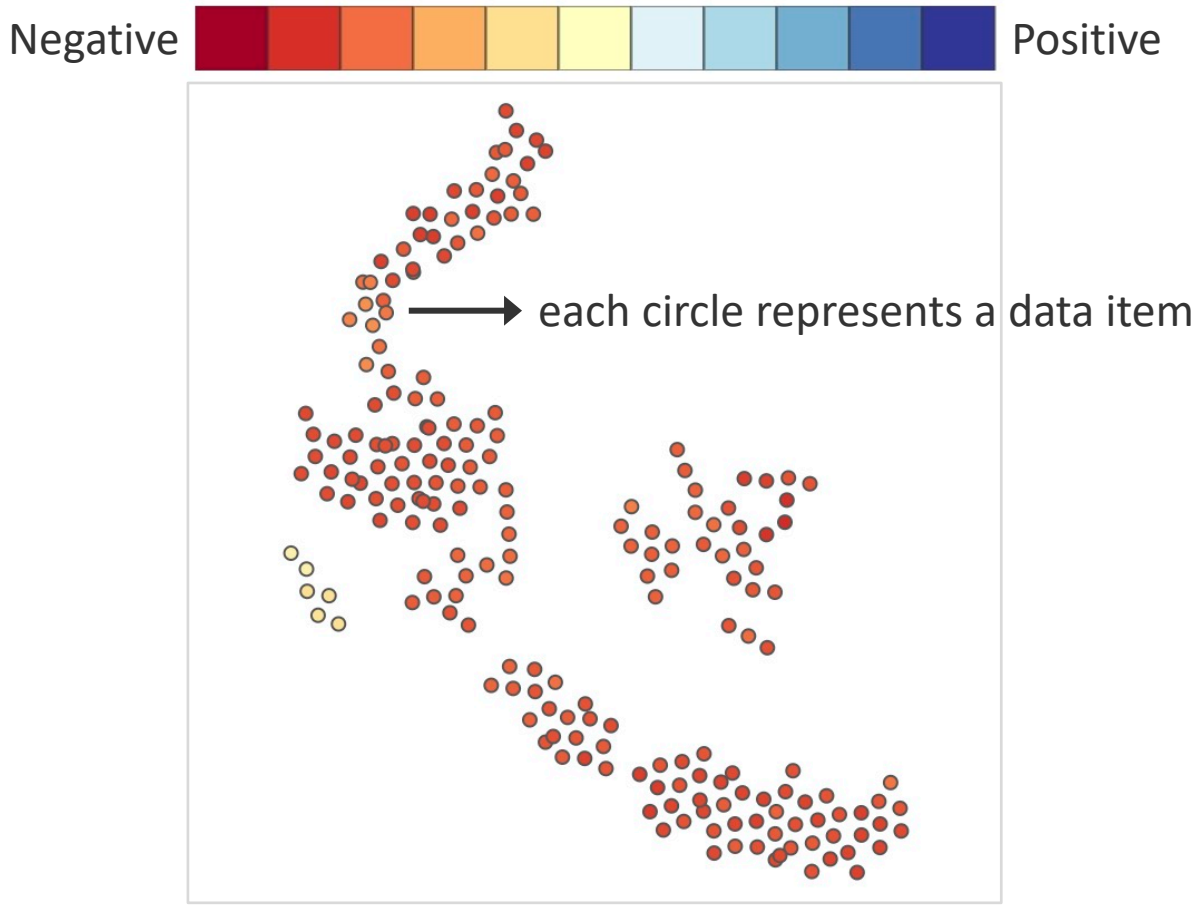
		Predicted Values: True	Predicted Values: False
Actual Values	**True**	True Positive	False Negative
Actual Values	**False**	False Positive	True Negative

iForest – Data Overview

- Methods: confusion matrix and t-sne projection



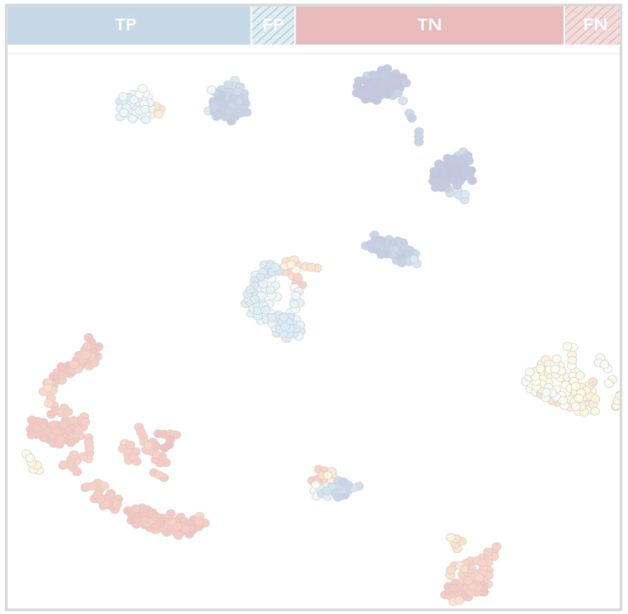
Default View



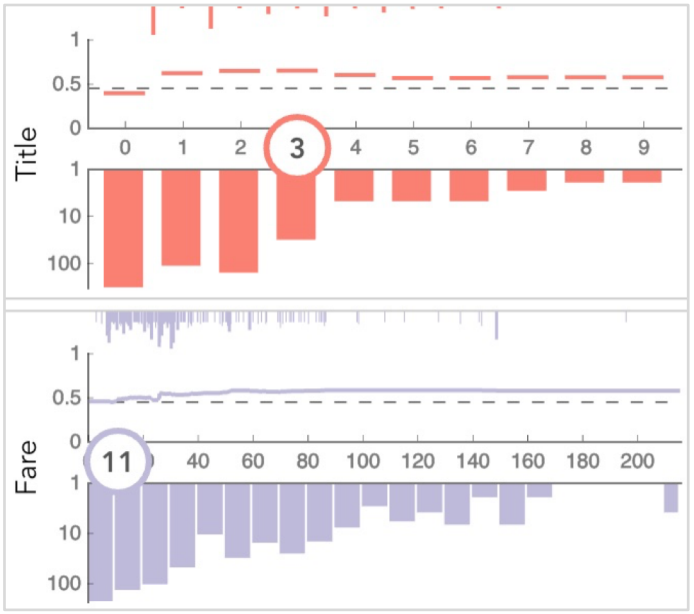
Panning & Zooming

iForest – Feature View

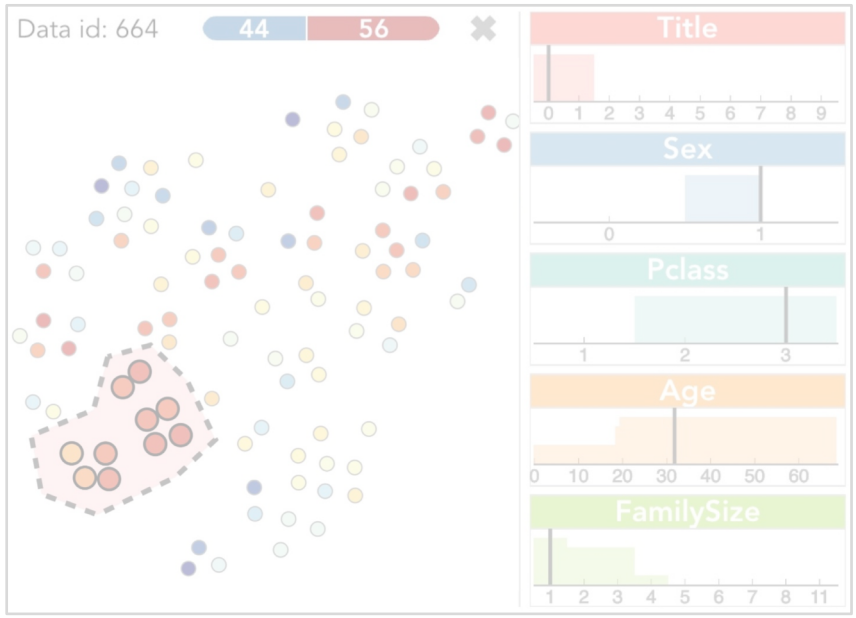
Data Overview



Feature View



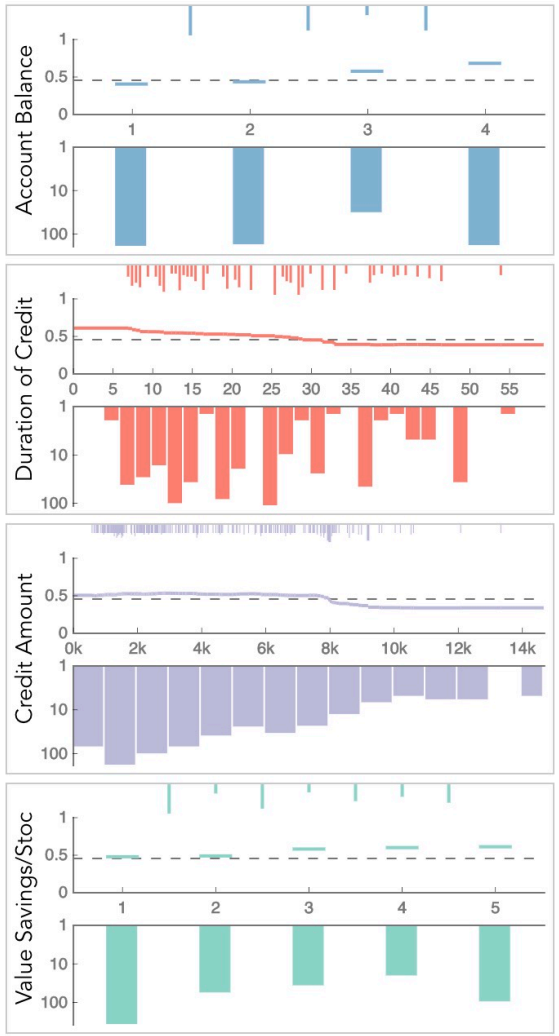
Decision Path View



- Reveal the relationships between features and predictions

iForest – Feature View

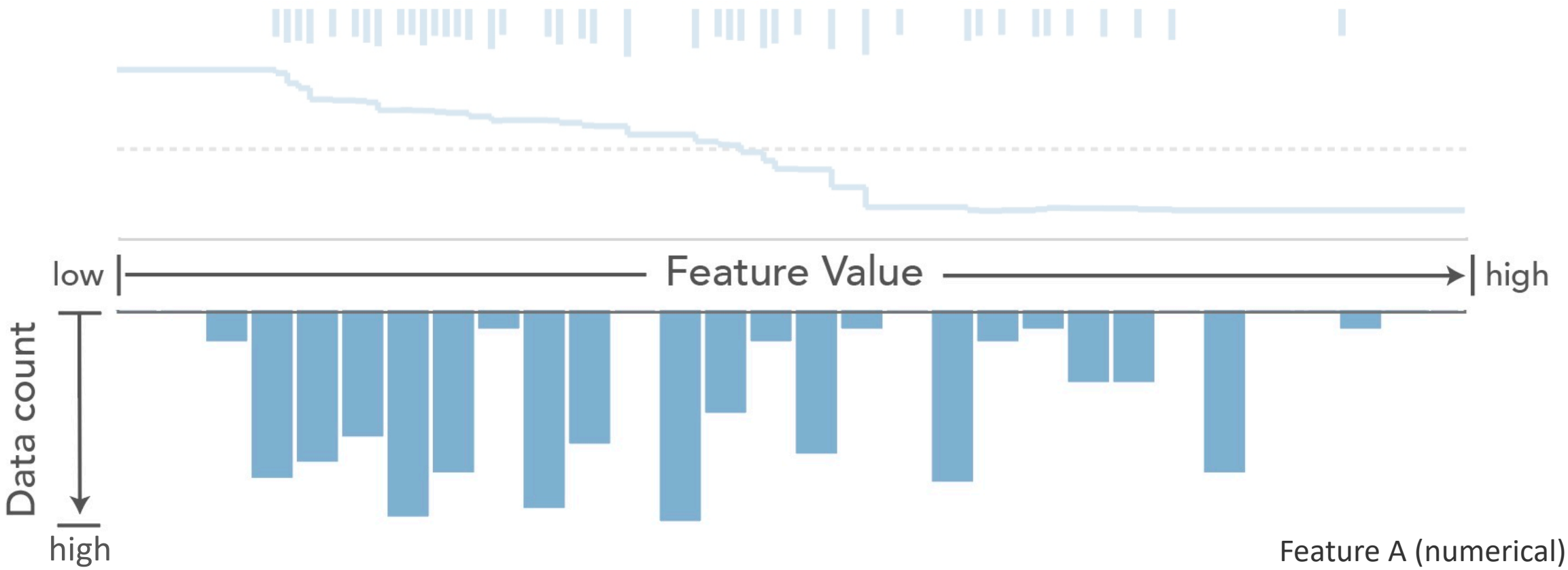
- Methods: data distribution and partial dependence plot



→ each cell illustrates the statistics and importance of a feature

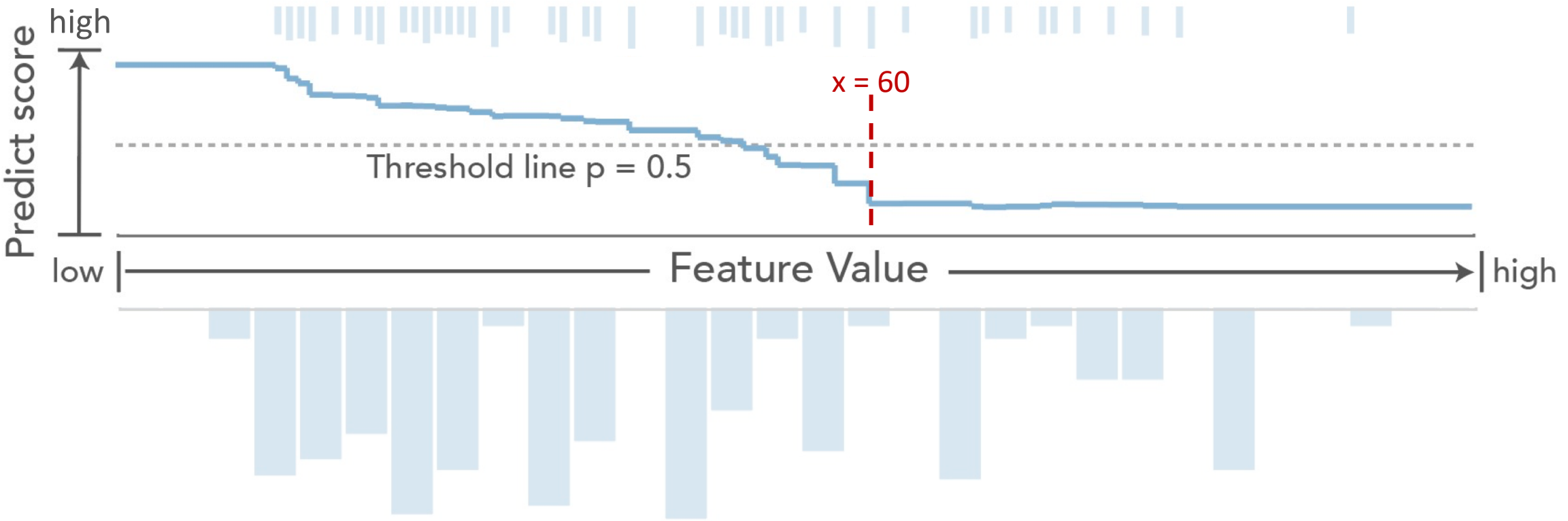
iForest – Feature View

- Methods: data distribution and partial dependence plot



iForest – Feature View

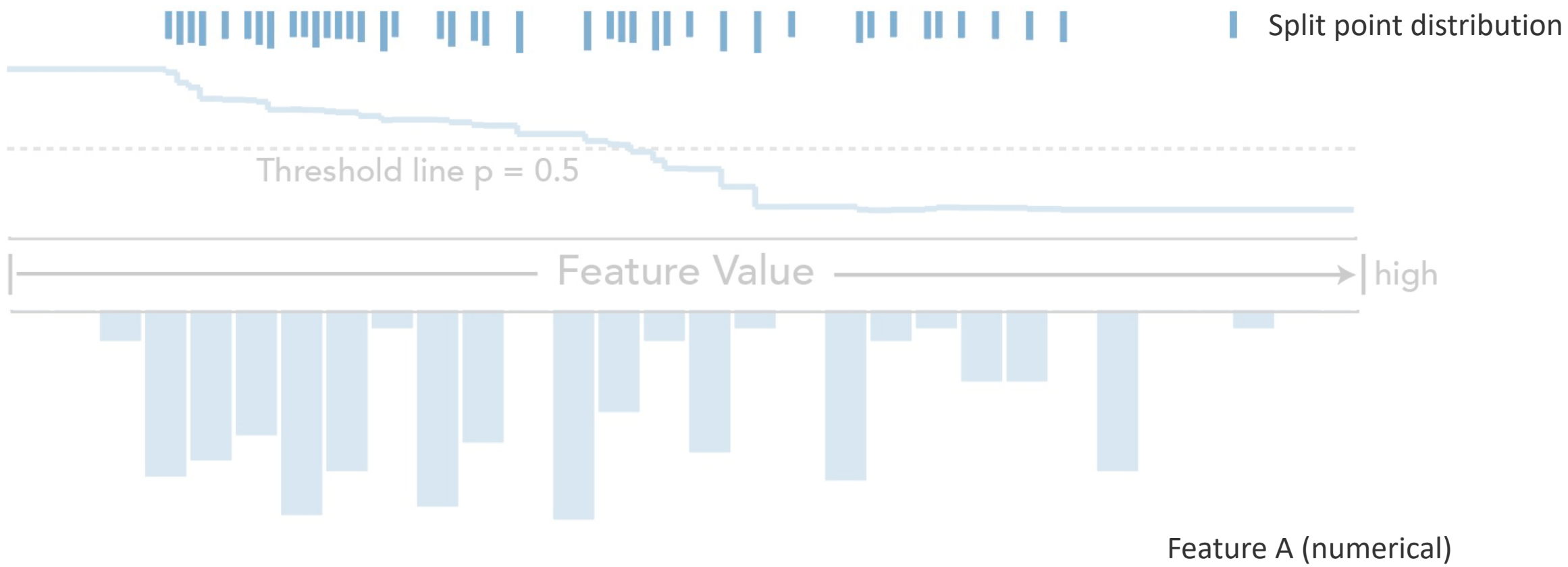
- Methods: data distribution and partial dependence plot



Feature A (numerical)

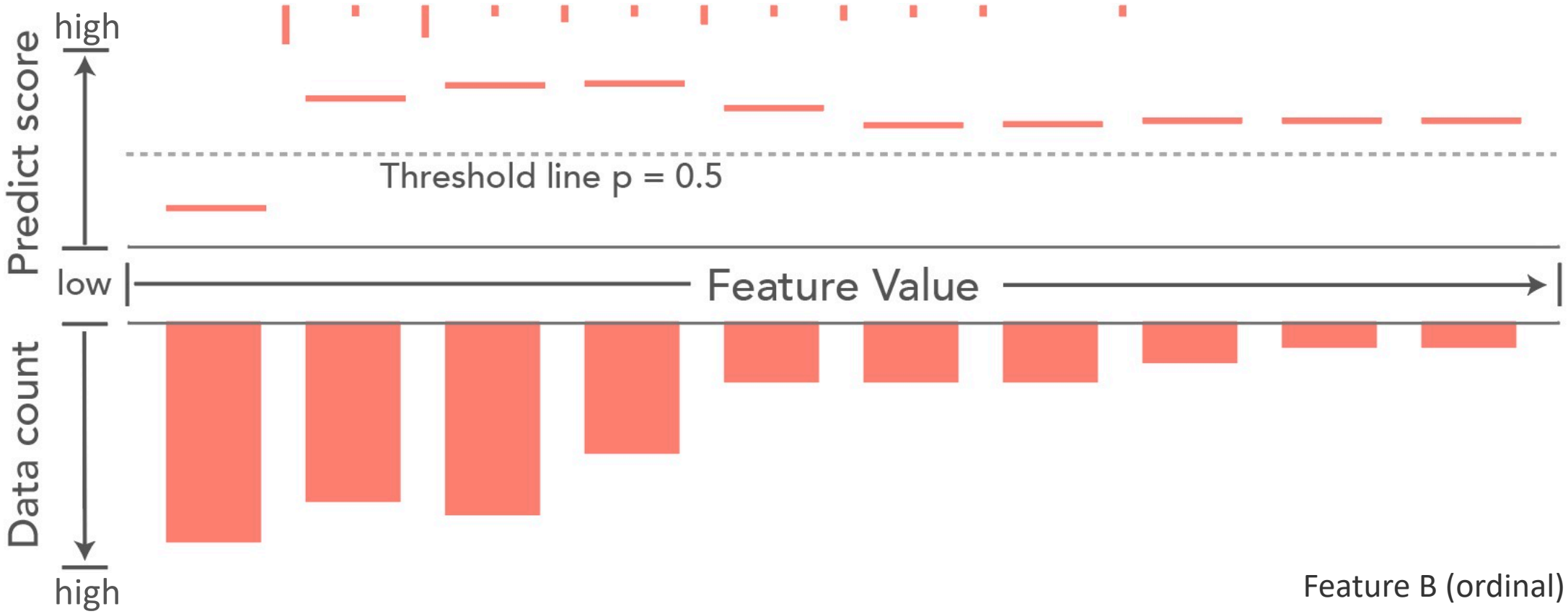
iForest – Feature View

- Methods: data distribution and partial dependence plot



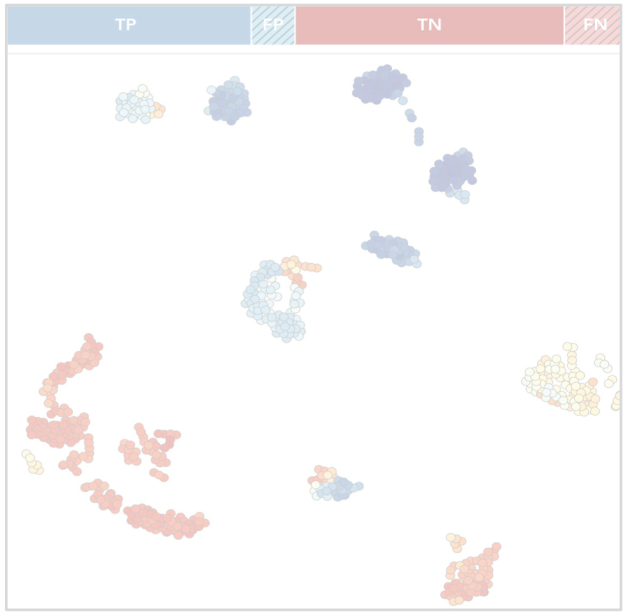
iForest – Feature View

- Methods: data distribution and partial dependence plot

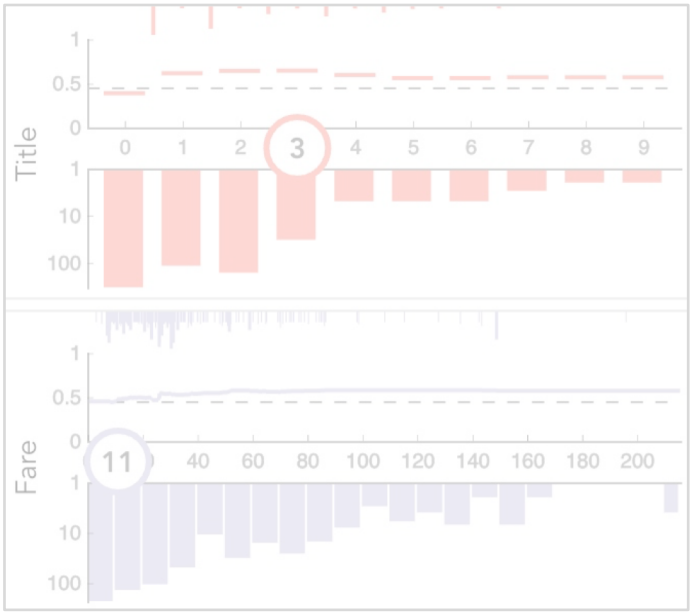


iForest – Feature View

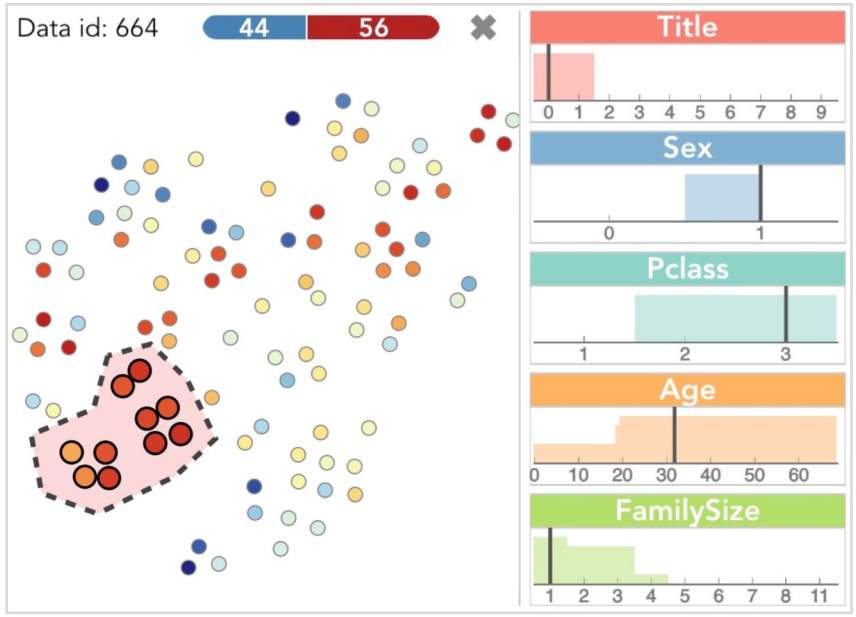
Data Overview



Feature View



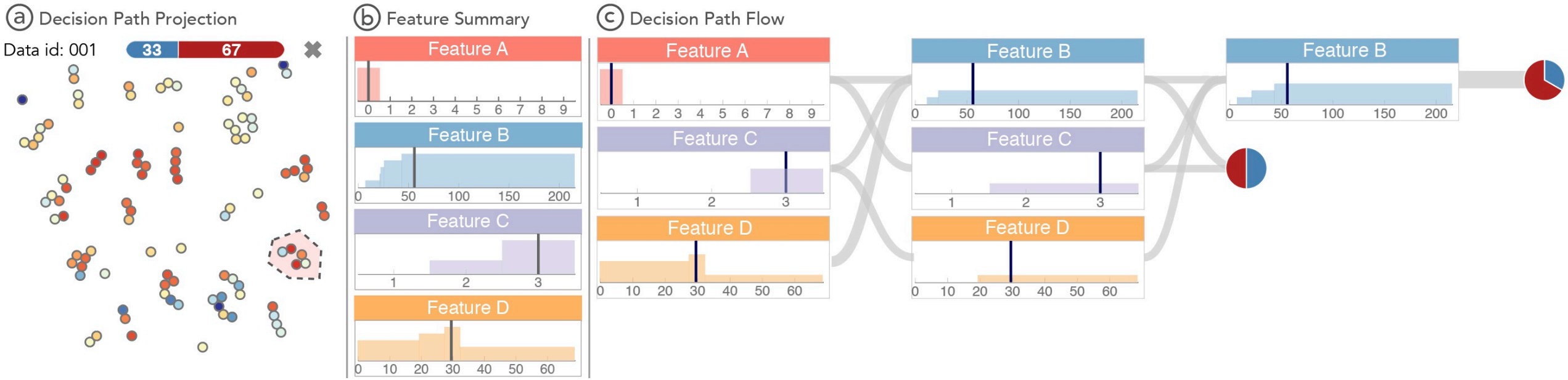
Decision Path View



Uncover the underlying working mechanisms

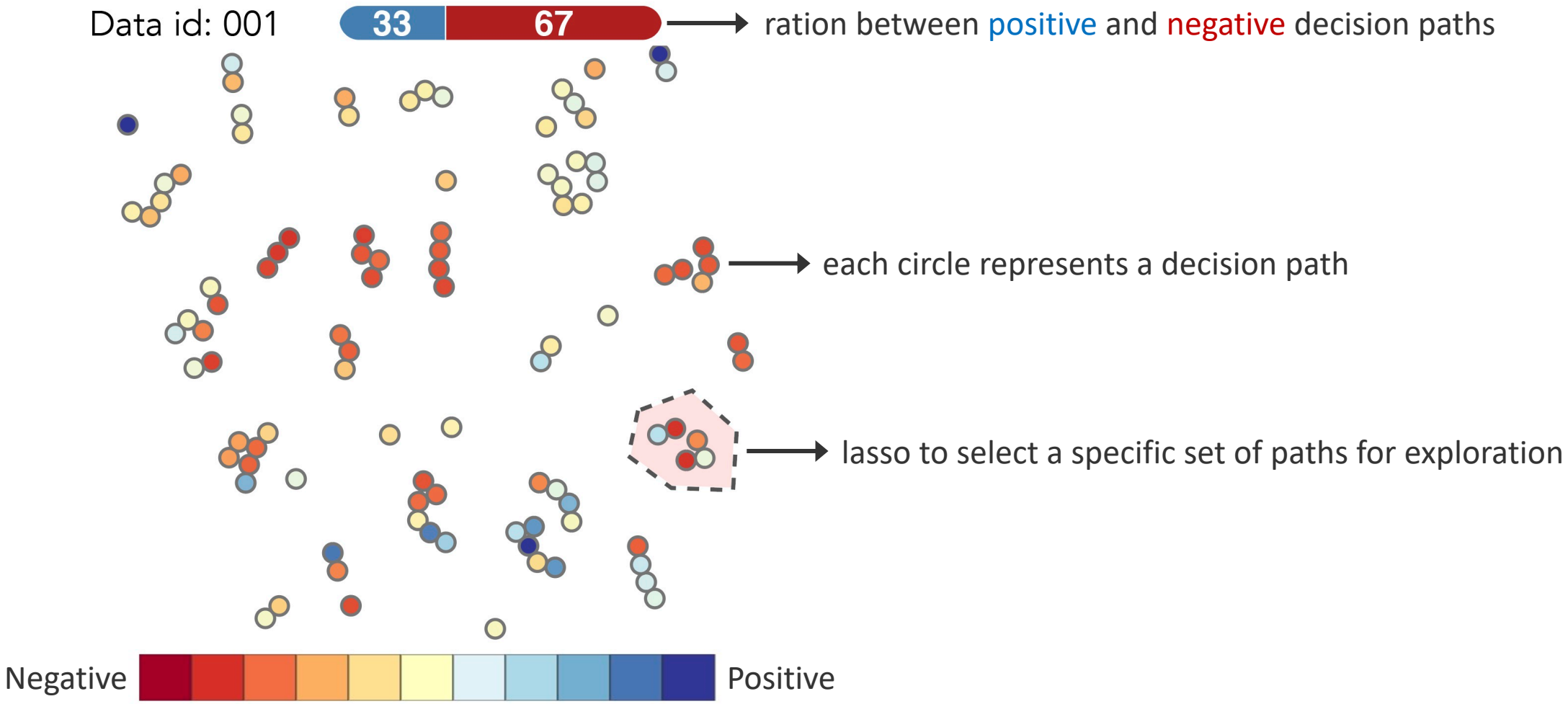
iForest – Decision Path View

- Goal: audit the decision process of a particular data item



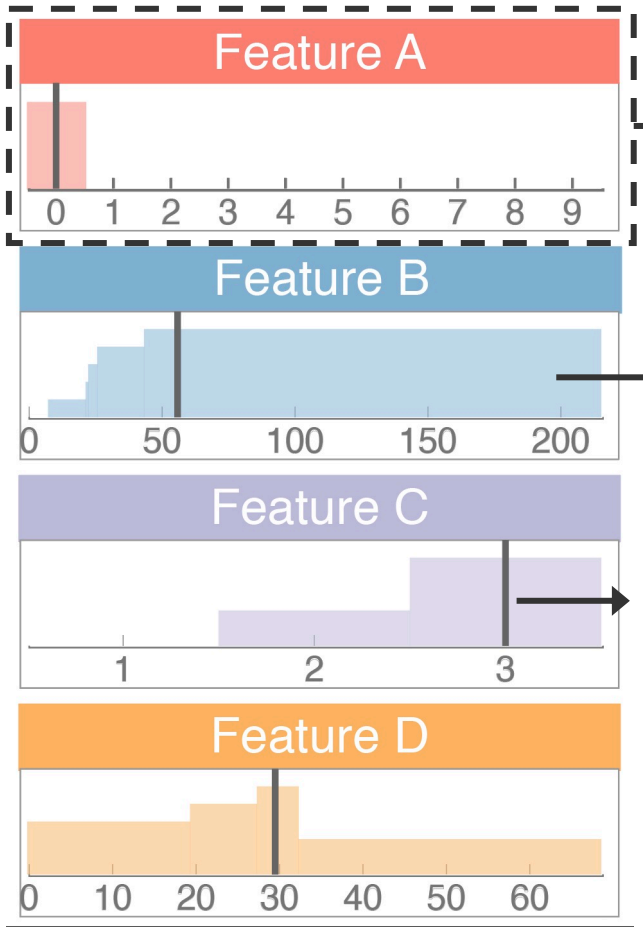
iForest – Decision Path View

- Decision Path Projection



iForest – Decision Path View

- Feature Summary



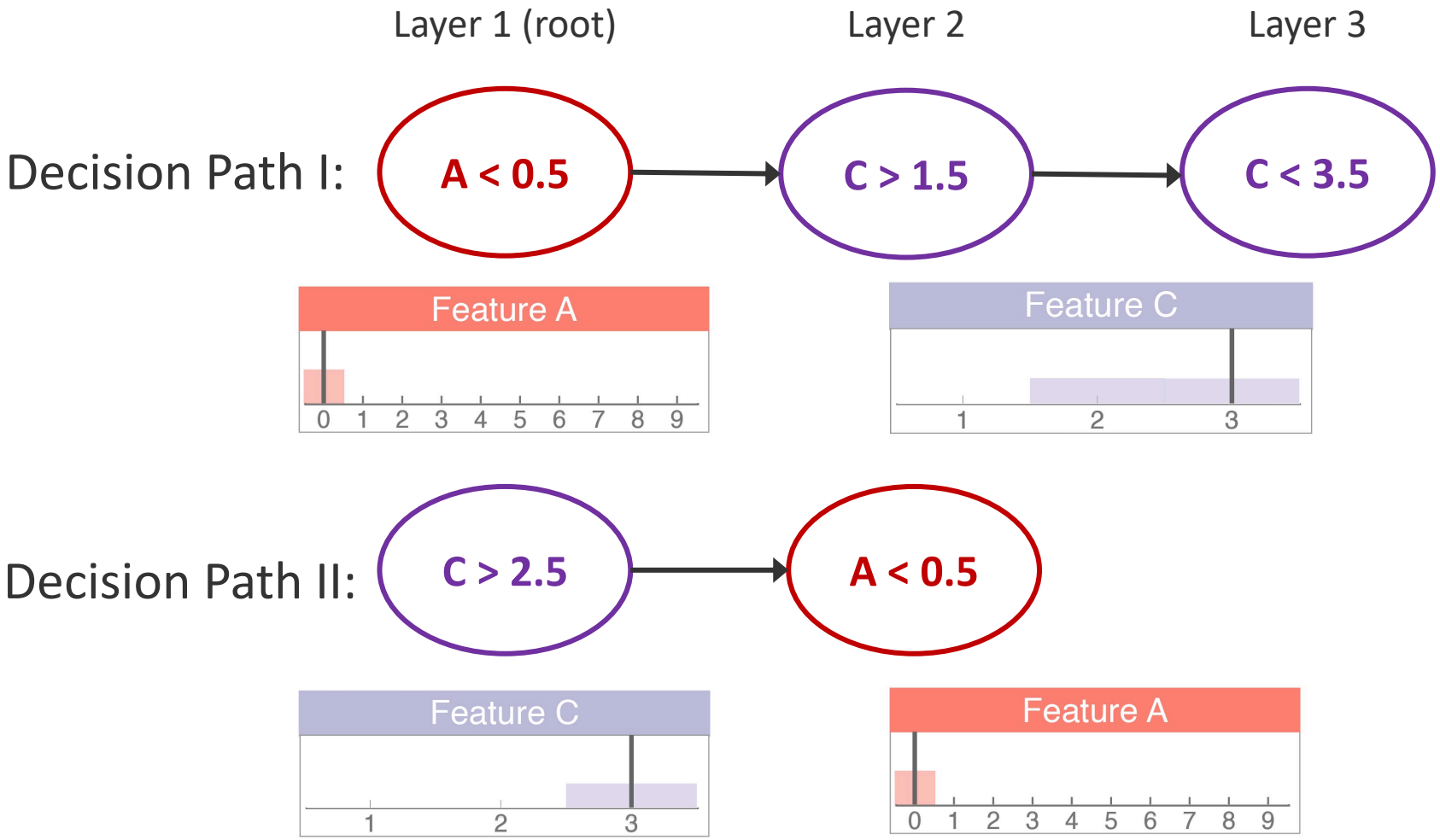
Feature Cell: Summarize the feature ranges of the selected paths

pixel-based bar chart: feature range summary

vertical bar: feature value of the current data item

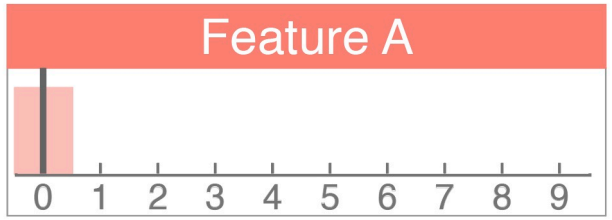
iForest – Decision Path View

- Feature Summary



iForest – Decision Path View

- Feature Summary



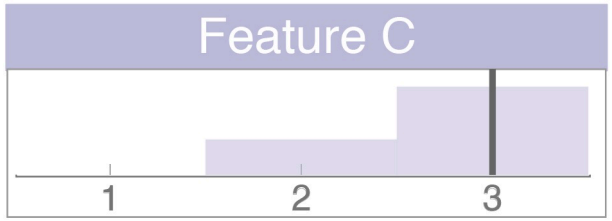
Layer 1 (root) Layer 2 Layer 3

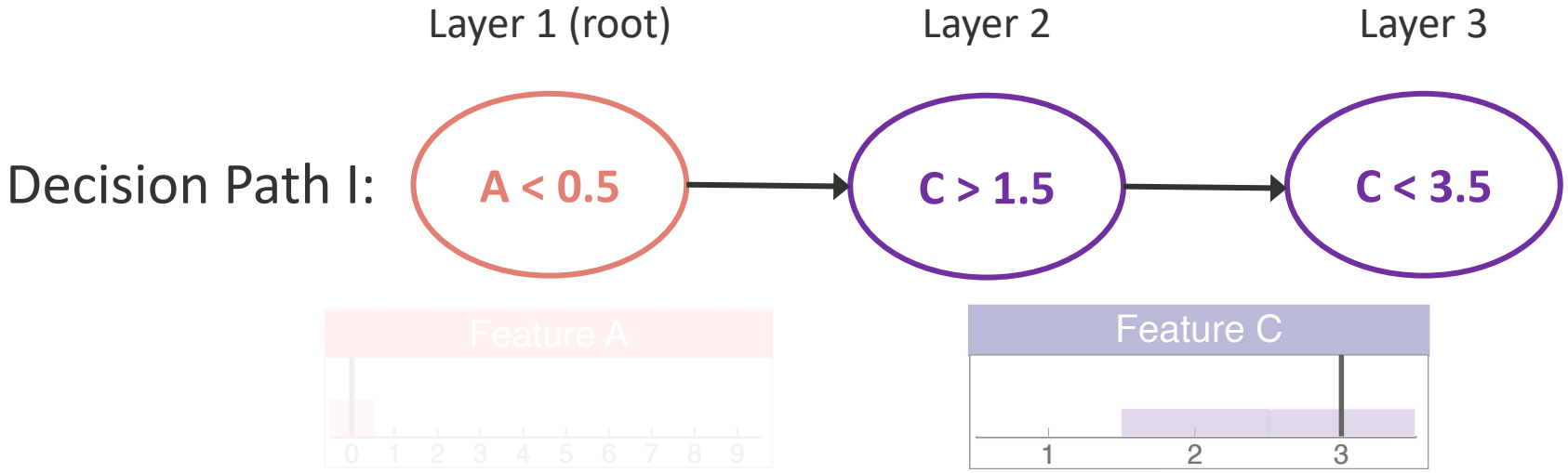
Decision Path I: A < 0.5 → C > 1.5 → C < 3.5

Decision Path II: C > 2.5 → A < 0.5

iForest – Decision Path View

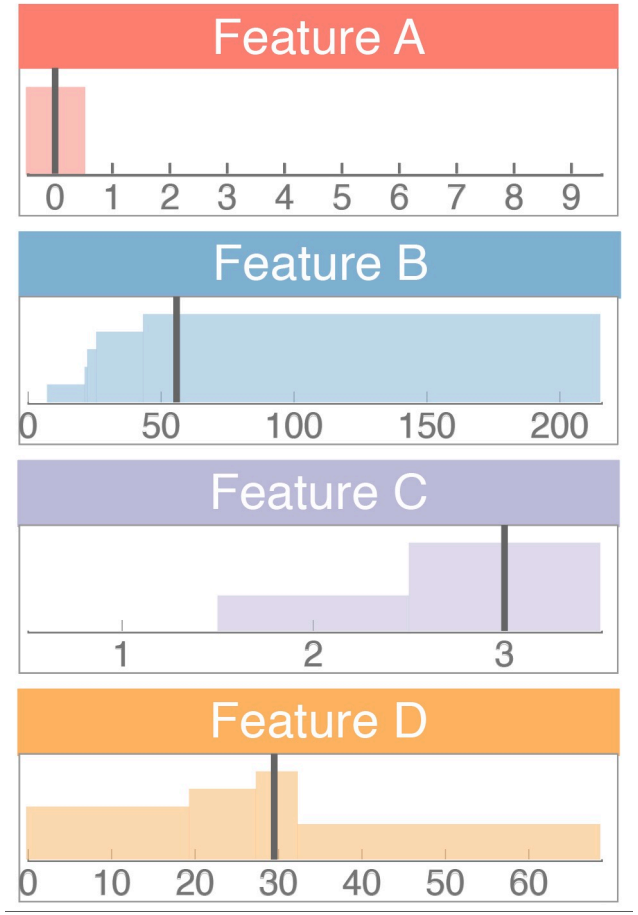
- Feature Summary

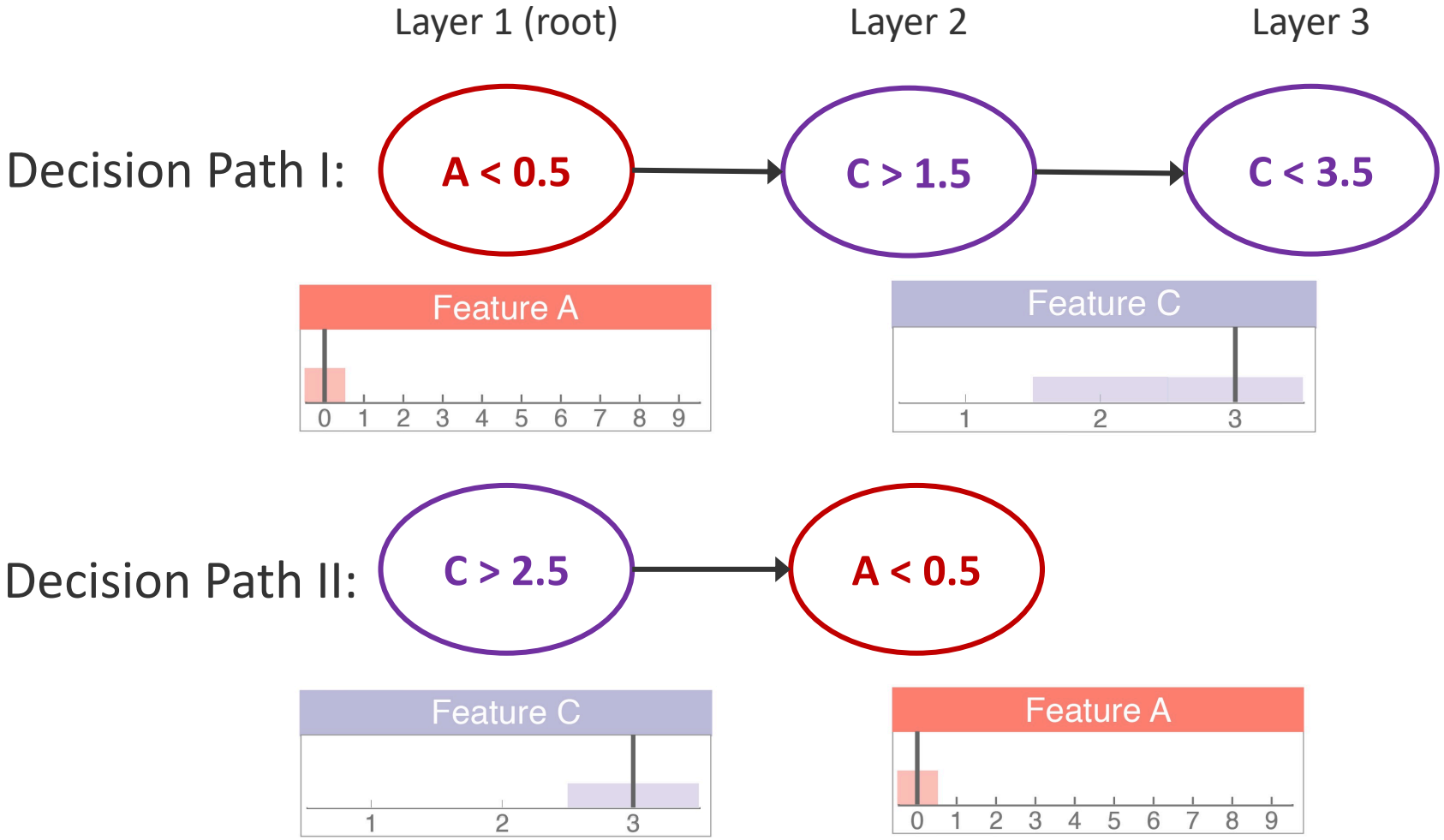




iForest – Decision Path View

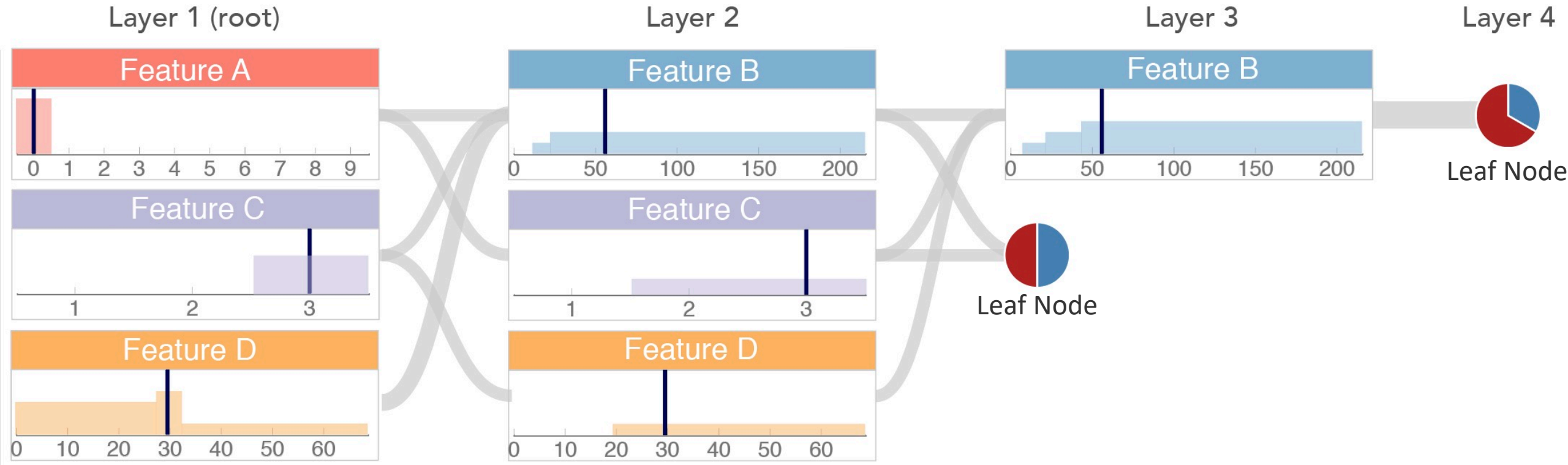
- Feature Summary





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

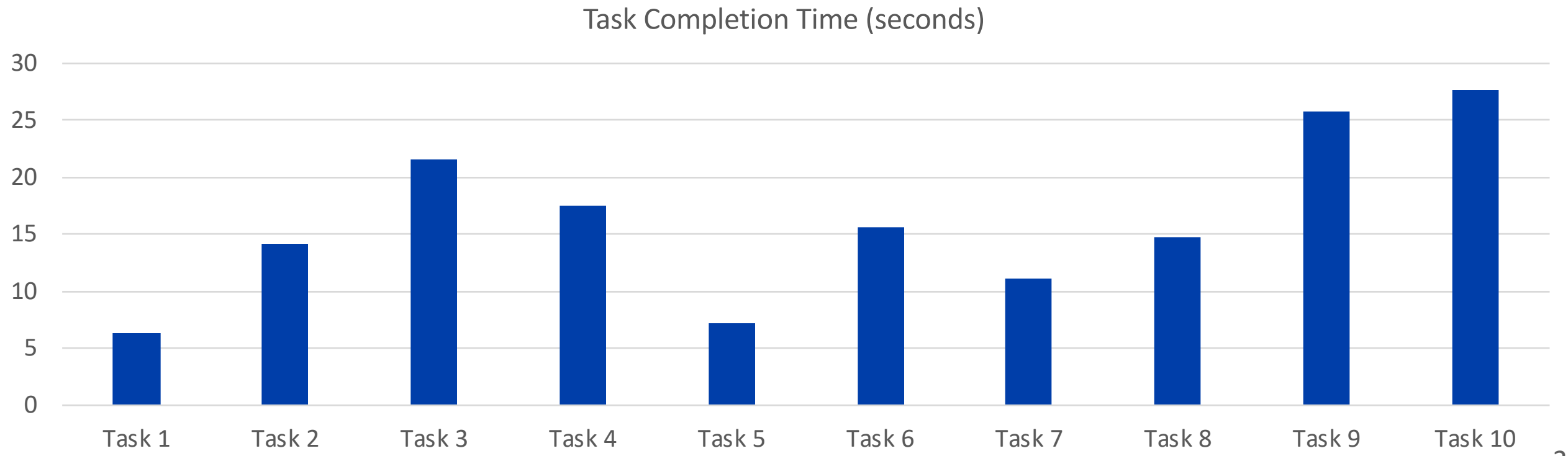
- Titanic shipwreck statistics:
  - 891 passengers and 6 features after pre-processing

- German Credit statistics:
  - 1,000 bank accounts and 9 features

Usage Scenario – Titanic

Evaluation – User Study

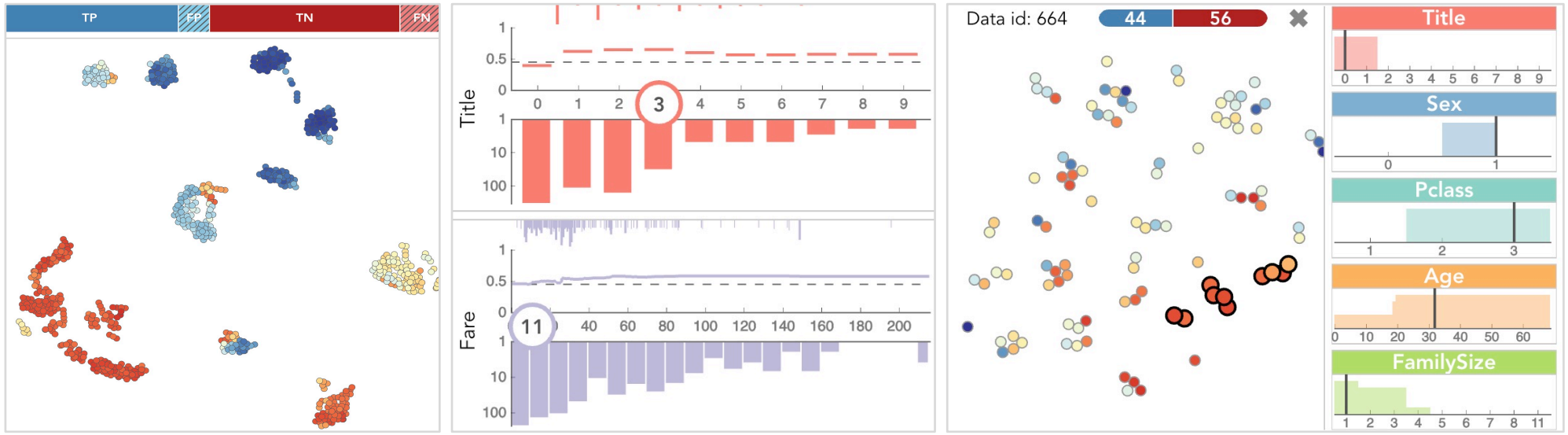
- Qualitative user study
  - 10 participants recruited from local university and an industry research lab
  - 10 tasks covering all important aspects in random forest interpretation
  - 12 questions related with iForest usage in a post-session interview



Future Work

- Support other tree-based model such as boosting trees
- Support multi-class classification or regression
- Support random forest diagnosis and debug

Q&A



iForest: Interpreting Random Forests via Visual Analytics

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