Supervised Learning with WEKA on Bakary Data

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CSE 352: Artificial Intelligence

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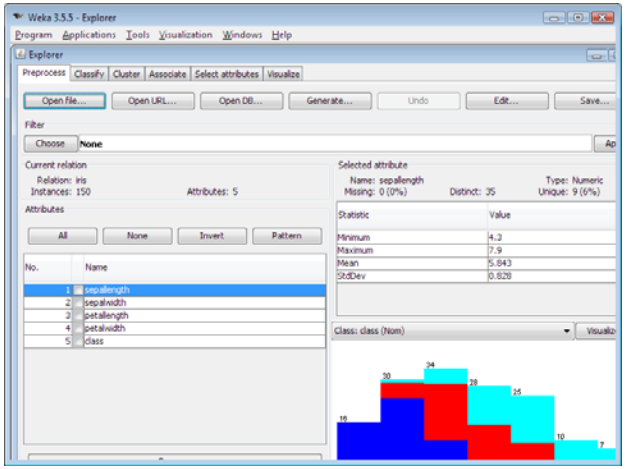
Outline

- Classification Tool: WEKA
- Data Preprocessing
  - Missing Data
  - Discretization
- Experiments
  - Methods
  - Decision Tree
  - Discriminant Rules
  - Predictive Accuracy
- Analysis

Classification Tool: WEKA



- The classification tool that I used was WEKA (the Waikato Environment for Knowledge Analysis)
- It can be obtained from http://www.cs.waikato.ac.nz/~ml/weka/index.html

Data Preprocessing: Missing Data

- Any attributes that had >= 80% of its values missing were removed

- Attribute CO had 85% of its values missing
- Attribute Mo had 89% of its values missing

- So, these attributes were removed

Data Preprocessing: Missing Data

- For any attribute that had < 80% of its values missing, the missing values were replaced with the mean (average) value
- These attributes included
  - TiO2, P2O5, S, Zn, Pb, Cu, As, Cd, Cr, Ni, Sc, V, Li
- Example
  - Mean value of TiO2 was 0.043
  - Any missing values in TiO2 were replaced with 0.043

Data Preprocessing: Discretization (using the tool WEKA)

- Data #1:
  - Binning Method
  - 3 Bins
  - Equal Depth (Frequency) Bins
- Data #2:
  - Binning Method
  - 3 Bins
  - Equal Width Bins

Data Preprocessing: Discretization

- For each bin, the values in the bin were replaced with the bin interval
- Example with CaO+MgO
  - Values were separated into 3 bins:
    - (48.64-inf)
    - (45.715-48.64]
    - (-inf-45.715]
  - Values in the “(48.64-inf)” bin were replaced with “(48.64-inf)”

Data Preprocessing

- Class values were replaced with simpler values to read
  - C1 <= R. Carbonatees and R.Carbonatees impures
  - C2 <= Pyrite
  - C3 <= Chalcopyrites
  - C4 <= Galene
  - C5 <= Spahlerite
  - C6 <= Sediments Terrigenes

Experiments

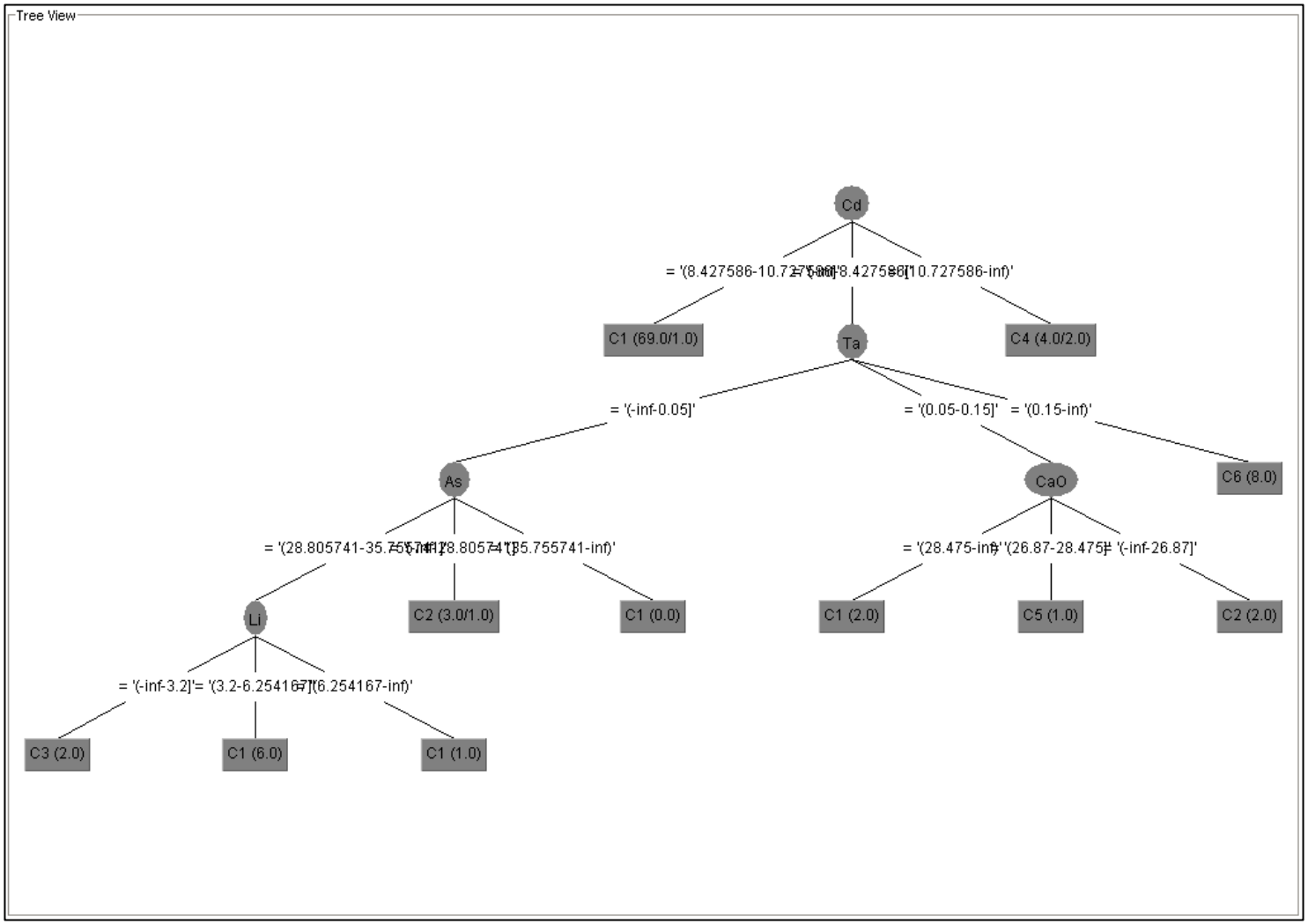
- Experiment 1 (Full Learning)
  - Use all attributes to classify all classes (C1-C6)
- Experiment 2 (Contrast Learning)
  - Use all attributes to contrast class C1 from the others
  - Class values C2-C6 were replaced with NOTC1
- Experiment 3
  - Use only the important attributes to classify all the classes (C1-C6)
  - According to the expert, the important attributes are S, Zn, Pb, Cu, CaO+MgO, CaO, MgO, Fe2O3

Experiment Methods

- Decision trees (and corresponding discriminant rules) were generated with the C4.5 algorithm

- Predictive accuracies were obtained by applying Leave-one-out on the data (and with the final predictive accuracy obtained by taking the average of all runs)

Experiment 1:
Data #1 - Decision Tree



Experiment 1:
Data #1 – 11 Discriminant Rules (1)

- IF Cd = “(8.427586-10.727586]”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Ta = “(-inf-0.05]”
  - AND As = “(28.805741-35.755741]” AND Li = “(-inf-3.2]”
  - THEN class = “C3”
- IF Cd = “(-inf-8.427586]” AND Ta = “(-inf-0.05]”
  - AND As = “(28.805741-35.755741]” AND Li = “(3.2-6.254167]”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Ta = “(-inf-0.05]”
  - AND As = “(28.805741-35.755741]” AND Li = “(6.254167-inf)”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Ta = “(-inf-0.05]”
  - AND As = “(-inf-28.805741]”
  - THEN class = “C2”

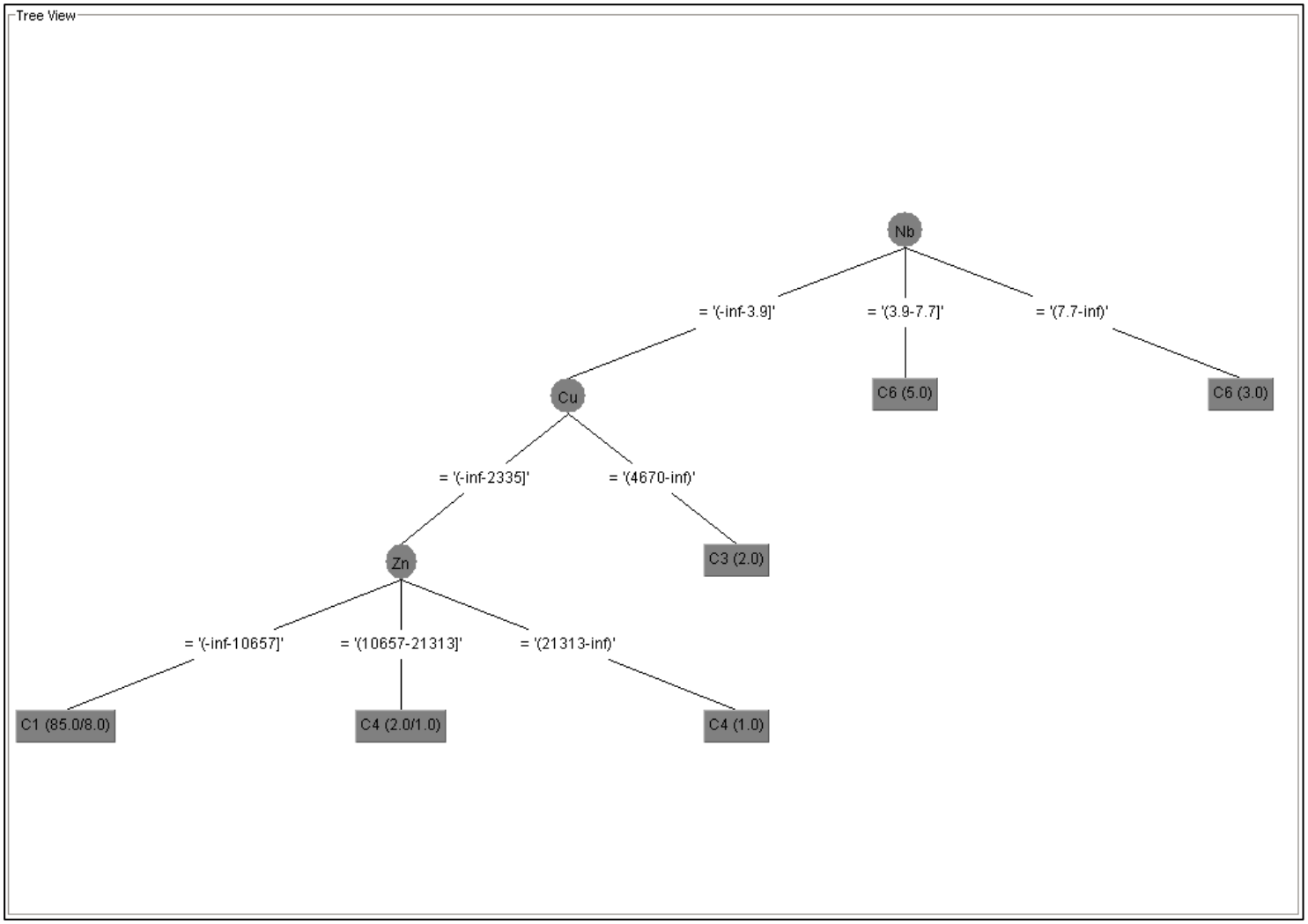
Experiment 1: Data #1 – 11 Discriminant Rules (2)

- IF Cd = “(-inf-8.427586]” AND Ta = “(-inf-0.05]”
  - AND As = “(35.755741-inf)” THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Ta = “(0.05-0.15]”
  - AND CaO = “(28.475-inf)” THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Ta = “(0.05-0.15]”
  - AND CaO = “(26.87-28.475]” THEN class = “C5”
- IF Cd = “(-inf-8.427586]” AND Ta = “(0.05-0.15]”
  - AND CaO = “(-inf-26.87]” THEN class = “C2”
- IF Cd = “(-inf-8.427586]” AND Ta = “(0.15-inf)”
  - THEN class = “C6”
- IF Cd = “(10.727586-inf)” THEN class = “C4”

Experiment 1:
Data #1 – Predictive Accuracy

- Applying Leave-one-out, the predictive accuracy of these rules was determined to be 88.7755%.

Experiment 1:
Data #2 - Decision Tree



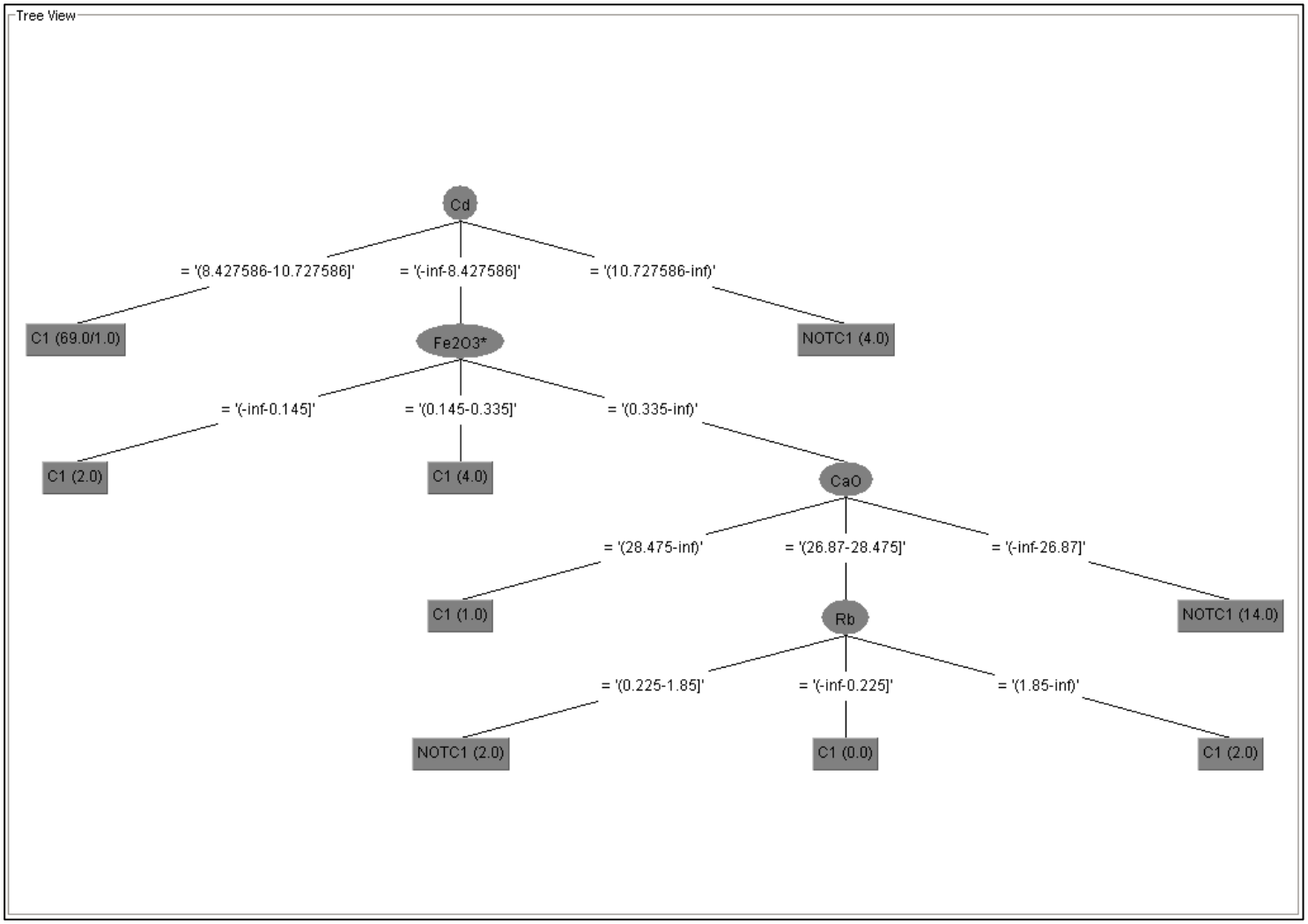
Experiment 1:
Data #2 – 6 Discriminant Rules

- IF Nb = “(-inf-3.9]” AND Cu = “(-inf-2335]
  - AND Zn = “(-inf-10657]” THEN class = “C1”
- IF Nb = “(-inf-3.9]” AND Cu = “(-inf-2335]”
  - AND Zn = “(10657-21313]” THEN class = “C4”
- IF Nb = “(-inf-3.9]” AND Cu = “(-inf-2335]”
  - AND Zn = “(21313-inf)” THEN class = “C4”
- IF Nb = “(-inf-3.9]” AND Cu = “(4670-inf)”
  - THEN class = “C3”
- IF Nb = “(3.9-7.7]” THEN class = “C6”
- IF Nb = “(7.7-inf)” THEN class = “C6”

Experiment 1:
Data #2 – Predictive Accuracy

- Applying Leave-one-out, the predictive accuracy of these rules was determined to be 84.6939%.

Experiment 2:
Data #1 - Decision Tree



Experiment 2:
Data #1 – 9 Discriminant Rules (1)

- IF Cd = “(8.427586-10.727586]” THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(-inf-0.145]”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(0.145-0.335]”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(0.335-inf)”
  - AND CaO = “(28.475-inf)” THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(0.335-inf)”
  - AND CaO = “(26.87-28.475]” AND Rb = “(0.225-1.85]”
  - THEN class = “NOTC1”

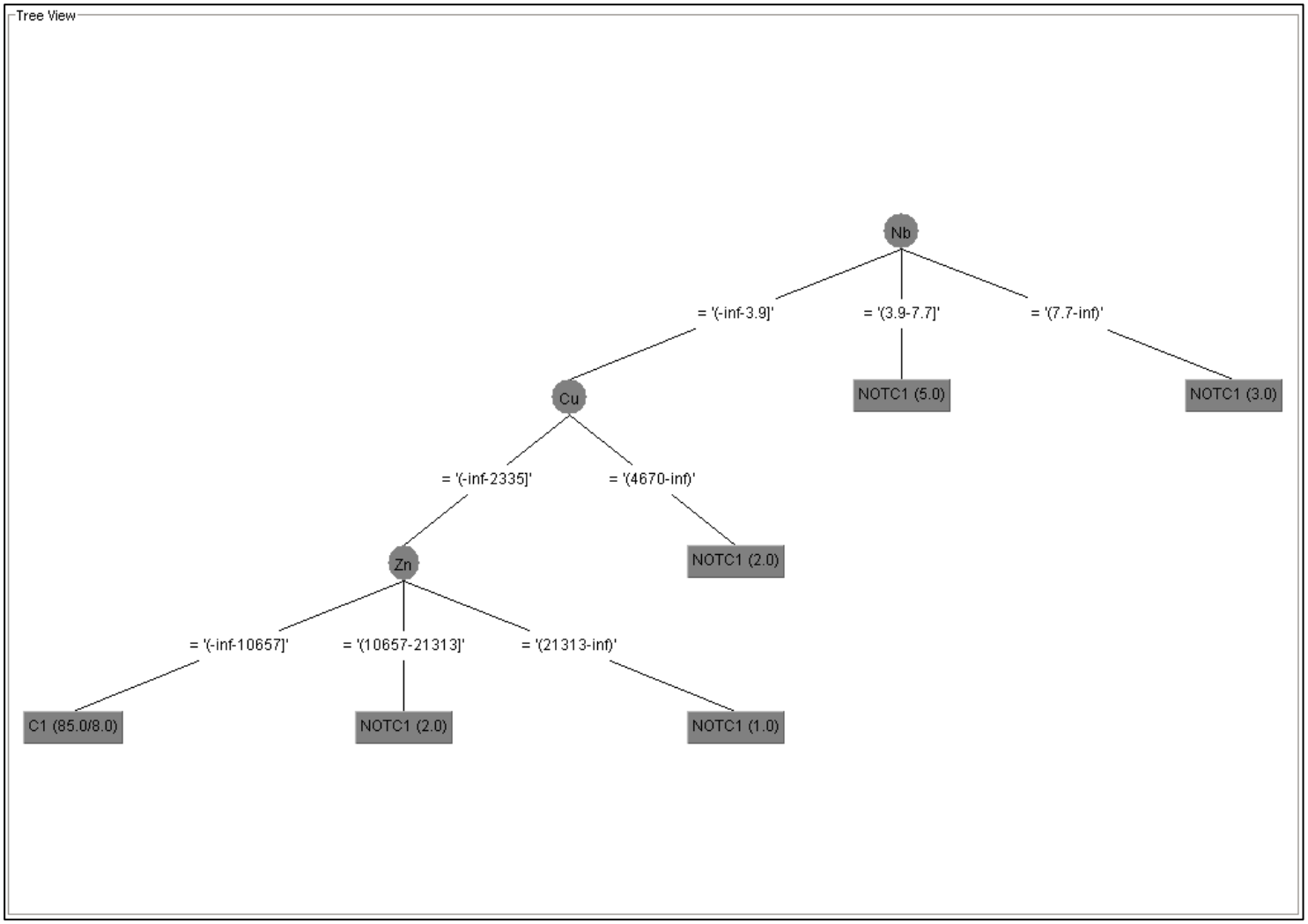
Experiment 2:
Data #1 – 9 Discriminant Rules (2)

- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(0.335-inf)”
  - AND CaO = “(26.87-28.475]” AND Rb = “(-inf-0.225]”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(0.335-inf)”
  - AND CaO = “(26.87-28.475]” AND Rb = “(1.85-inf)”
  - THEN class = “C1”
- IF Cd = “(-inf-8.427586]” AND Fe2O3* = “(0.335-inf)”
  - AND CaO = “(-inf-26.87]” THEN class = “NOTC1”
- IF Cd = “(10.727586-inf)” THEN class = “NOTC1”

Experiment 2:
Data #1 – Predictive Accuracy

- Applying Leave-one-out, the predictive accuracy of these rules was determined to be 92.8571%.

Experiment 2:
Data #2 - Decision Tree



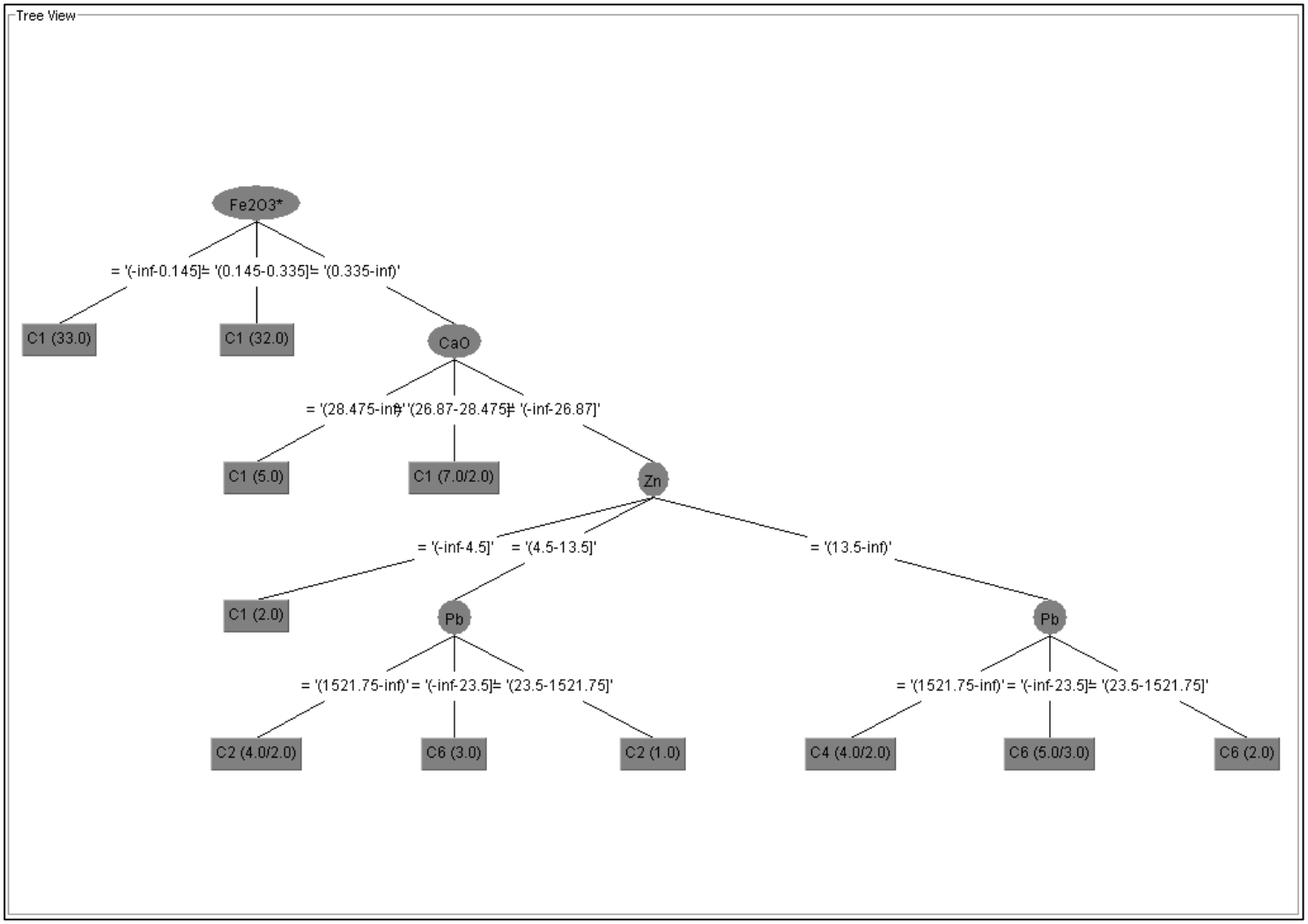
Experiment 2:
Data #2 – 6 Discriminant Rules

- IF Nb = “(-inf-3.9]” AND Cu = “(-inf-2335]”
  - AND Zn = “(-inf-10657]” THEN class = “C1”
- IF Nb = “(-inf-3.9]” AND Cu = “(-inf-2335]”
  - AND Zn = “(10657-21313]” THEN class = “NOTC1”
- IF Nb = “(-inf-3.9]” AND Cu = “(-inf-2335]”
  - AND Zn = “(21313-inf)” THEN class = “NOTC1”
- IF Nb = “(-inf-3.9]” AND Cu = “(4670-inf)”
  - THEN class = “NOTC1”
- IF Nb = “(3.9-7.7]” THEN class = “NOTC1”
- IF Nb = “(7.7-inf)” THEN class = “NOTC1”

Experiment 2:
Data #2 – Predictive Accuracy

- Applying Leave-one-out, the predictive accuracy of these rules was determined to be 84.6939%.

Experiment 3:
Data #1 - Decision Tree



Experiment 3:
Data #1 – 11 Discriminant Rules (1)

- IF Fe2O3* = “(-inf-0.145]” THEN class = “C1”
- IF Fe2O3* = “(0.145-0.335]” THEN class = “C1”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(28.475-inf)”
  - THEN class = “C1”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(26.87-28.475]”
  - THEN class = “C1”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(-inf-4.5]” THEN class = “C1”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(4.5-13.5]” AND Pb = “(1521.75-inf)”
  - THEN class = “C2”

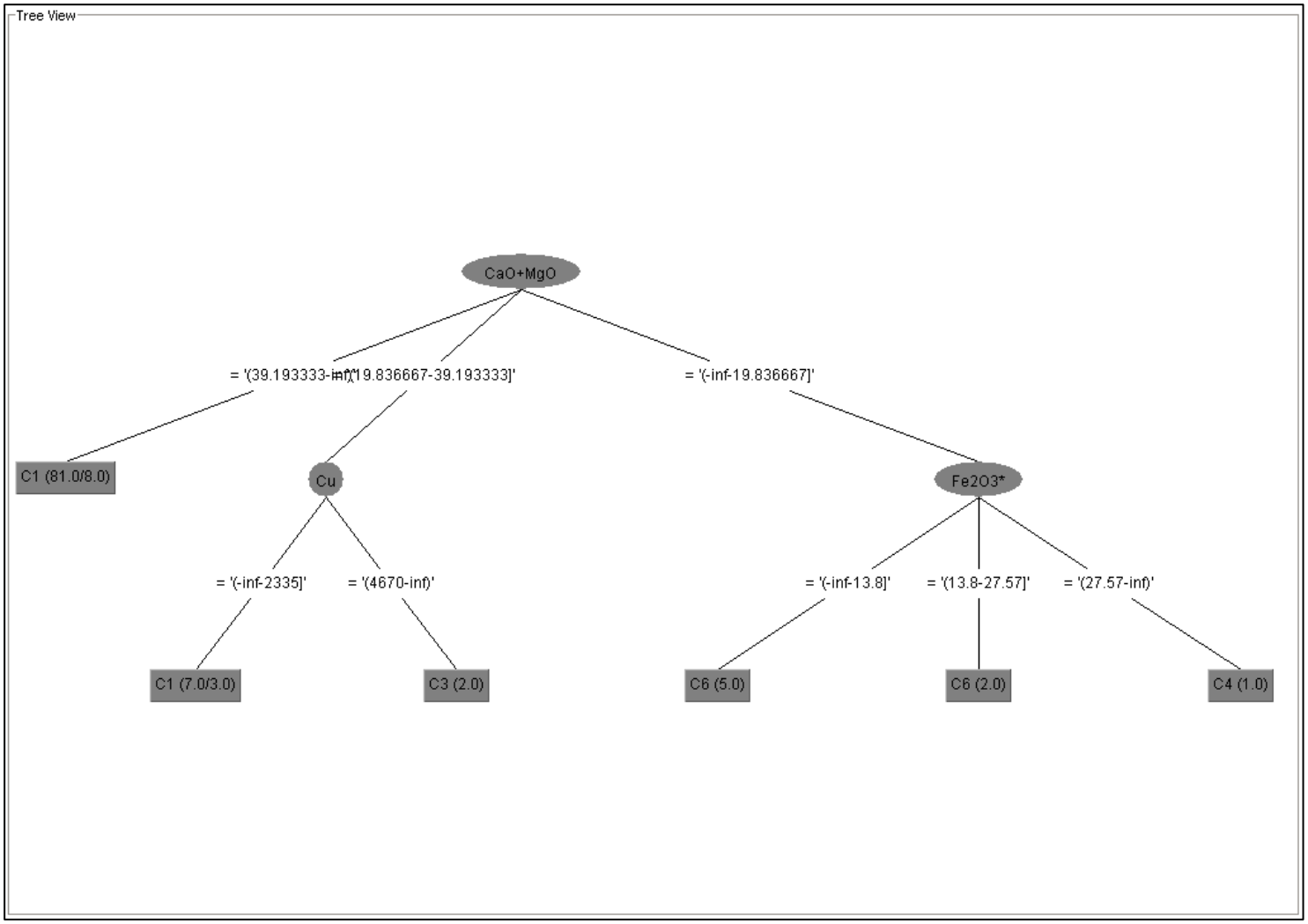
Experiment 3:
Data #1 – 11 Discriminant Rules (2)

- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(4.5-13.5]” AND Pb = “(-inf-23.5]”
  - THEN class = “C6”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(4.5-13.5]” AND Pb = “(23.5-1521.75]”
  - THEN class = “C2”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(13.5-inf)” AND Pb = “(1521.75-inf)”
  - THEN class = “C4”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(13.5-inf)” AND Pb = “(-inf-23.5]”
  - THEN class = “C6”
- IF Fe2O3* = “(0.335-inf)” AND CaO = “(-inf-26.87]”
  - AND Zn = “(13.5-inf)” AND Pb = “(23.5-1521.75]”
  - THEN class = “C6”

Experiment 3:
Data #1 – Predictive Accuracy

- Applying Leave-one-out, the predictive accuracy of these rules was determined to be 83.6735%.

Experiment 3:
Data #2 - Decision Tree



Experiment 3:
Data #2 – 6 Discriminant Rules

- IF CaO+MgO = “(39.193333-inf)” THEN class = “C1”
- If CaO+MgO = “(19.836667-39.193333]”
  - AND Cu = “(-inf-2335]” THEN class = “C1”
- If CaO+MgO = “(19.836667-39.193333]”
  - AND Cu = “(4670-inf)” THEN class = “C3”
- IF CaO+MgO = “(-inf-19.836667]”
  - AND Fe2O3* = “(-inf-13.8]” THEN class = ‘C6”
- IF CaO+MgO = “(-inf-19.836667]”
  - AND Fe2O3* = “(13.8-27.57]” THEN class = “C6”
- IF CaO+MgO = “(-inf-19.836667]”
  - AND Fe2O3* = “(27.57-inf)” THEN class = “C4”

Experiment 3:
Data #2 – Predictive Accuracy

- Applying Leave-one-out, the predictive accuracy of these rules was determined to be 85.7143%.

Experiments: Summary of Predictive Accuracy (Leave-one-out)

	Data #1 3 Bins Equal Depth	Data #2 3 Bins Equal Width
Experiment 1	88.7755%	84.6939%
Experiment 2	92.8571%	84.6939%
Experiment 3	83.6735%	85.7143%

Analysis

- The high rule accuracy can be misleading
  - A lot of data about one class, but not the others
    - 77 records about class C1
    - Only 21 records about classes C2-C6
- Contrasting one class against all others may generate more accurate rules than comparing all classes simultaneously
- Notice how we started out with 48 attributes about each data record
  - In the end, we reduced it to only 3 to 5 attributes to classify the data