Some Thoughts on Action
Rule Mining

Ryan Benton
March 10, 2014
Action Rules

• Goal
  – Determine what changes must be made to attributes to change the decision result.

• Expressed
  – \( \{a, x_1 \rightarrow x_2\} \Rightarrow \{t_1 \rightarrow t_2\} \)
    • If \( a \) occurs and \( x_1 \) becomes \( x_2 \), then \( t_1 \) will become \( t_2 \).
    • \( \{\text{dark}, \text{drunk} \rightarrow \text{not\_drunk}\} \Rightarrow \{\text{accident} \rightarrow \text{no\_accident}\} \)
Association Mining Concepts
Concepts

- **Item**
  - An attribute-value that appears in the ‘database’

- **Itemset**
  - A set composed of one or more items

- **K-itemset**
  - Itemset composed of k items.
Measures

• Support
  – How many times has an itemset appeared in the data (database).
  – Expressed
    • Support \((A \Rightarrow B) = \text{Count}(A \cup B)\)
    • Support \((A \Rightarrow B) = P(A \cup B)\)
    • Note
      – Support\((A \cup B) = \text{Count}(A \cup B)\)
      – Support \((A \cup B) = P(A \cup B)\)
Measures

• Confidence
  – For a Rule
    • Percentage of cases in which a consequent appears given that the antecedent has occurred
  – Expressed
    • Confidence \((A \Rightarrow B) = P(B|A)\)
    • Confidence \((A \Rightarrow B) = \text{Support}(A \cup B) / \text{Support}(A)\)
Return to Concepts

• MinSup
  – The minimum support required for an itemset to be considered *frequent*.

• MinCon
  – The minimum confidence required for an rule to be considered *strong*.
Action Rule Methods
Action Rules

• Rule
  \[ \{a, x_1 \rightarrow x_2\} \Rightarrow \{t_1 \rightarrow t_2\} \]

• A number of different methods exist.
  – Most from group run by Dr. Zbigniew W. Raś.

• Many use support-confidence framework
Concepts

• Attributes
  – Stable: Value may not change.
  – Flexible: Values may be changed
  – Decision: Which values are desired to change.

• User Specifies
  – Stable
  – Flexible
  – Decision (normally)
Concepts

• Action-Item
  – May be either
    • Stable value
    • Flexible value
    • Transition (flexible value → flexible value)

• Action Set
  – A set composed of one or more action-items

• K-Action Set
  – Action Set composed of k action-items
Concepts

• MinSup
  – The minimum support required for an action set to be considered frequent.

• MinCon
  – The minimum confidence required for an action rule to be considered strong.

• No Consistent Definitions!!!!
More Formally

- $t_1, t_2$ are two atomic action sets
- $t = t_1 \cdot t_2$ is an action set.
- Domain of the action set $t$
  - $\text{Dom}(t) = \text{Dom}(t_1) \bigcup \text{Dom}(t_2)$
  - *Note: Cannot have two different static values for same attribute.*
More Formally

• Rule: \( t_1 \rightarrow t_2 \)
  
  – \( N_s(t_1) = [A_1, A_2] \)
    • A1: All single values and for the antecedent values of all transition values.
    • A1: All single values and for the conditional values of all transition values.
  
  – \( N_s(t_2) = [Z_1, Z_2] \)
    • Z1: All single values and for the antecedent values of all transition values.
    • Z1: All single values and for the conditional values of all transition values.
Example

• Assume
  – Static Values: a1
  – Flexible Values: b1, b2, c1, c2, d1, d2
• \([a1, b1 \rightarrow b2] \Rightarrow [c1, d1 \rightarrow d2]\)
  – A1 = [a1, b1]
  – A2 = [a1, b2]
  – Z1 = [c1, d1]
  – Z2 = [c1, d2]
Measures
ARD Measures

• Support
  – Support(t1) = card(A1)
    • t1 = Ns(A1, A2)
  – Support(t1 ⇒ t2) = card(A1 ∩ Z1)
    • t1 = Ns(A1, A2)
    • t2 = Ns(Z1, Z2)

• Confidence
  – conf(r) = \( \frac{\text{card}(A1 \cap Z1)}{\text{card}(A1)} \times \frac{\text{card}(A2 \cap Z2)}{\text{card}(A2)} \)
  – where Conf(r) = Conf(t1 ⇒ t2)
AAR Measures

• Support
  – Support \( t_1 \) = min(\( \text{card}(A_1) \), \( \text{card}(A_2) \))
    • \( t_1 = \text{Ns}(A_1, A_2) \)
  – Support( \( t_1 \Rightarrow t_2 \) ) = min(\( \text{card}(A_1 \cap Z_1) \), \( \text{card}(A_2 \cap Z_2) \))
    • \( t_1 = \text{Ns}(A_1, A_2), t_2 = \text{Ns}(Z_1, Z_2) \)

• Confidence
  – \( \text{conf} (r) = \frac{\text{card}(A_1 \cap Z_1)}{\text{card}(A_1)} \times \frac{\text{card}(A_2 \cap Z_2)}{\text{card}(A_2)} \)
  – where \( \text{Conf}(r) = \text{Conf}(t_1 \Rightarrow t_2) \)
ARED Measures

• Support
  – \( \text{Support}(t_1 \Rightarrow t_2) = \min(\text{card}(A_1 \cap Z_1), \text{card}(A_2 \cap Z_2)) \)

• Confidence
  – \( \text{Support}(t_1 \Rightarrow t_2) / \text{card}(A_1 \cap Z_1) \)
FAARM Measures

• Support
  – Support (t1) = \text{card}(A1) \times \text{card}(A2)
    • t1 = Ns(A1, A2)
  – Support (t1 \Rightarrow t2) = \text{card}(A1 \cap Z1) \times \text{card}(A2 \cap Z2)
    • t1 = Ns(A1, A2), t2 = Ns(Z1, Z2)

• Confidence
  – \text{Supp}(t1 \Rightarrow t2) / \text{Supp}(t1)
Relationships Between Measures
## Support -- Identical

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Support – Other Relationships

• AAR Support is subset of
  – ARD
  – FAARM

• FAARM and ARED Overlap
New Support and Confidence

• Suggested by Dr. Alaaeldin Hafez
Conditional Probability

- \( P(A|B) = \frac{P(A \cap B)}{P(B)} \)

- If independent, \( P(A \cap B) = P(A)P(B) \)

- Thus, \( P(A|B) = P(A) \)
Project Ideas

• Compare/Contrast Methods

• Compare/Contrast Measures

• Develop New Measures/Methods
Contact

• Ryan Benton

• rbenton at louisiana.edu

• Room 205, Oliver Hall
References


• D. Difallah, R. Benton, T. Johnsten and V. Raghavan, “FAARM: Frequent Association Action Rules Mining Using FP-Tree”, in *Workshop of Domain Driven Data Mining (part of 11th International Conference on Data Mining Workshops)*, 2011, pp. 398-404