Overview of Data Analytics: Data Mining & Warehousing

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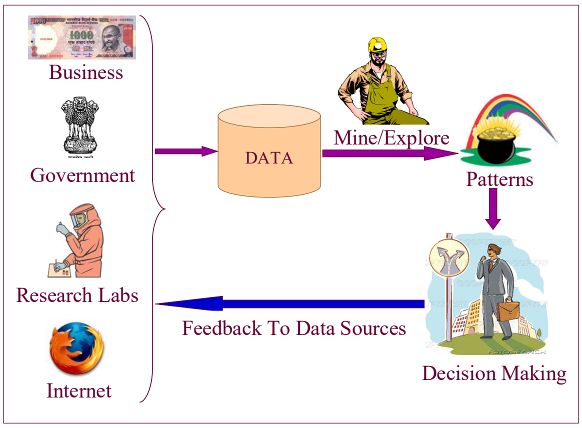
Originated from DB community…

- Traditional Database Systems
  - Indexing
  - Query languages
  - Query optimization
  - Transaction processing
  - Recovery …
- XML, Semantic web
- OO and OR DBMS …
- *Data Mining*

Data Mining

Automated extraction of interesting patterns from large databases



Types of Patterns

- Associations
  - *Coffee* buyers usually also purchase *sugar*
- Clustering
  - Segments of customers requiring different promotion strategies
- Classification
  - Customers expected to be *loyal*

Association Rules

That which is infrequent is not worth worrying about.

Association Rules

D :

Transaction ID	Items
1	Tomato, Potato, Onions
2	Tomato, Potato, Brinjal, Pumpkin
3	Tomato, Potato, Onions, Chilly
4	Lemon, Tamarind

Rule: Tomato, Potato → Onion (confidence: 66%, support: 50%)

Support(X) = |transactions containing X| / |D|
Confidence(R) = support(R) / support(LHS(R))

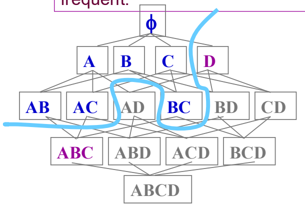
Problem proposed in [AIS 93]: Find all rules satisfying user given minimum support and minimum confidence.

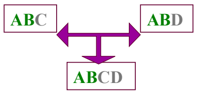
Association Rule Applications

- E-commerce
  - People who have bought *Sundara Kandam* have also bought *Srimad Bhagavatham*
- Census analysis
  - *Immigrants* are usually *male*
- Sports
  - A chess end-game configuration with "*white pawn on A7*" and "*white knight dominating black rook*" typically results in a "*win for white*".
- Medical diagnosis
  - Allergy to *latex rubber* usually co-occurs with allergies to *banana* and *tomato*

The Apriori Algorithm

Idea: An itemset can be frequent only if all its subsets are frequent.



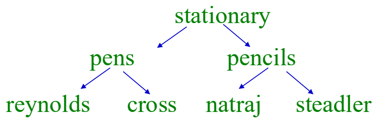


```
Apriori( DB, minsup ):
C = {all 1-itemsets}
        // candidates = singletons
while ( |C| > 0 ):
    make pass over DB, find counts of C
    F = sets in C with count ≥ minsup*|DB|
    output F
    C = AprioriGen(F) // gen. candidates
```

```
AprioriGen( F ):
for each pair of itemsets X, Y in F:
   if X and Y share all items, except last
      Z = X ∪ Y // generate candidate
      if any imm. subset of Z is not in F:
         prune Z // Z can't be frequent
```

Types of Association Rules

- Boolean association rules
- Hierarchical rules



reynolds → pencils

- Quantitative & Categorical rules
  - (Age: 30…39), (Married: Yes) → (NumCars: 2)

More Types of Association Rules

- Cyclic / Periodic rules
  - Sunday → vegetables
  - Christmas → gift items
  - Summer, rich, jobless → ticket to Hawaii
- Constrained rules
  - Show itemsets whose average price > Rs.10,000
  - Show itemsets that have television on RHS
- Sequential rules
  - Star wars, Empire Strikes Back → Return of the Jedi

Classification

To be or not to be: That is the question.

- William Shakespeare

The Classification Problem

Outlook	Temp (°F)	Humidity (%)	Windy?	Class
sunny	75	70	true	*play*
sunny	80	90	true	*don't play*
sunny	85	85	false	*don't play*
sunny	72	95	false	*don't play*
sunny	69	70	false	*play*
overcast	72	90	true	*play*
overcast	83	78	false	*play*
overcast	64	65	true	*play*
overcast	81	75	false	*play*
rain	71	80	true	*don't play*
rain	65	70	true	*don't play*
rain	75	80	false	*play*
rain	68	80	false	*play*
rain	70	96	false	*play*
sunny	77	69	true	?
rain	73	76	false	?

Play Outside?

Model relationship between class labels and attributes

e.g. outlook = overcast ⇒ class = *play*

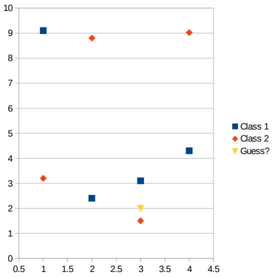
⇒ Assign class labels to new data with *unknown* labels

Applications

- Text classification
  - Classify emails into spam / non-spam
  - Classify web-pages into yahoo-type hierarchy
  - NLP Problems
    - Tagging: Classify words into verbs, nouns, etc.
- Risk management, Fraud detection, Computer intrusion detection
  - Given the properties of a transaction (items purchased, amount, location, customer profile, etc.)
  - Determine if it is a fraud
- Machine learning / pattern recognition applications
  - Vision
  - Speech recognition
  - etc.
- All of science & knowledge is about predicting future in terms of past
  - So classification is a very fundamental problem with ultra-wide scope of applications

k-Nearest Neighbours

- Model = Training data
- Classify record R using the *k* nearest neighbours of R in the training data.
- Most frequent class among *k* NNs
- Distance function could be euclidean
- Use an index structure (e.g. R* tree) to find the *k* NNs efficiently



Decision Trees

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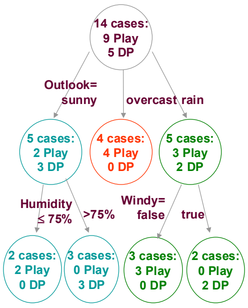

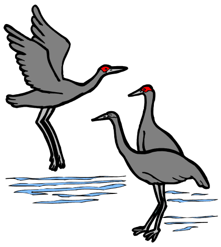

Clustering

Birds of a feather flock together.

The Clustering Problem

Outlook	Temp (°F)	Humidity (%)	Windy?
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sunny	85	85	false
sunny	72	95	false
sunny	69	70	false
overcast	72	90	true
overcast	73	88	true
overcast	64	65	true
overcast	81	75	false
rain	71	80	true
rain	65	70	true
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Find groups of similar records.

Need a function to compute similarity, given 2 input records

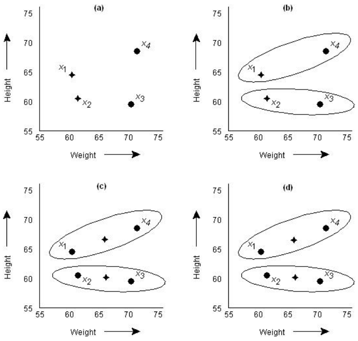
⇒ Unsupervised learning

Applications

- Targetting similar people or objects
  - Student tutorial groups
  - Hobby groups
  - Health support groups
  - Customer groups for marketing
  - Organizing e-mail
- Spatial clustering
  - Exam centres
  - Locations for a business chain
  - Planning a political strategy

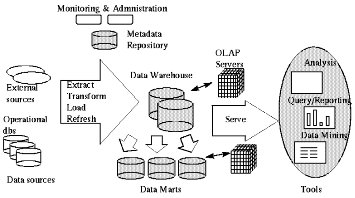
Partitioning technique: *k*-Means

- Initial *k* means = random records
- Iterate as long as clusters change:
  - Put each record X in the cluster to whose mean it is closest
  - Recompute means as the average of all points in each cluster



Data Warehousing

- Extract, transform, load data from multiple sources in an enterprise
- Provide unified view for top management
- OLAP server provides multi-dimensional view for manual exploration of patterns



Examples of OLAP

Comparisons (this period v.s. last period)

Show me the sales per store for this year and compare it to that of the previous year to identify discrepancies

Ranking and statistical profiles (top N/bottom N)

Show me sales, profit and average call volume per day for my 10 most profitable salespeople

Custom consolidation (market segments, ad hoc groups)

Show me an abbreviated income statement by quarter for the last four quarters for my northeast region operations

Take Home

- Data mining is a mature field
- Don’t waste time developing new algorithms for core tasks
- Focus on applications to challenging kinds of data
  - Streams, Distributed data, Multimedia, Web, …
- Most effort is in how to map domain problems to data mining problems
- And how to make sense of the output.