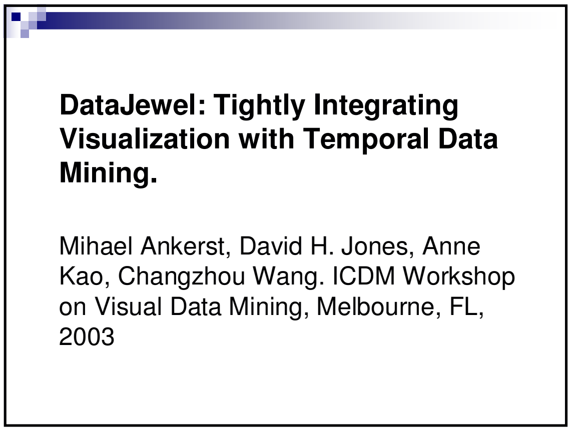
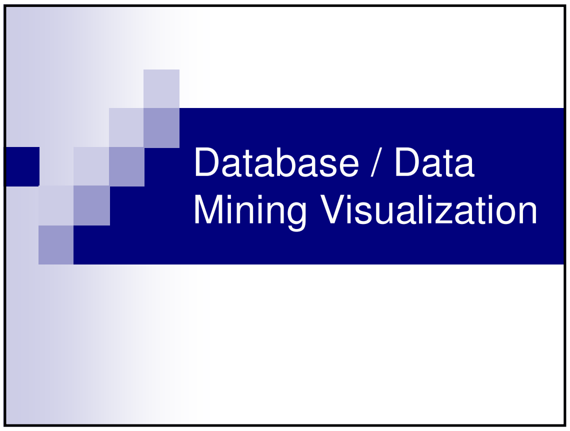
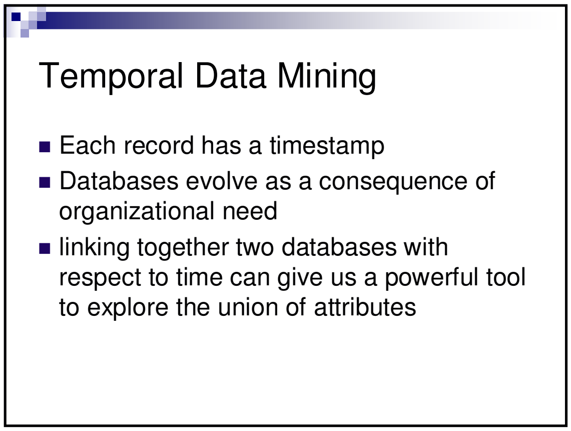


DataJewel: Tightly Integrating Visualization with Temporal Data Mining.

Mihael Ankerst, David H. Jones, Anne Kao, Changzhou Wang. ICDM Workshop on Visual Data Mining, Melbourne, FL, 2003

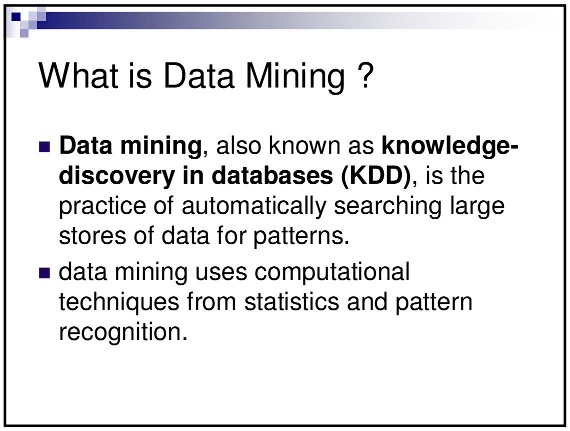


Database / Data Mining Visualization



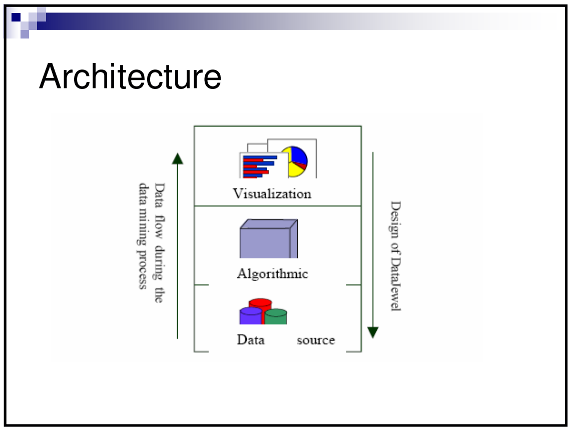
Temporal Data Mining

- Each record has a timestamp
- Databases evolve as a consequence of organizational need
- linking together two databases with respect to time can give us a powerful tool to explore the union of attributes

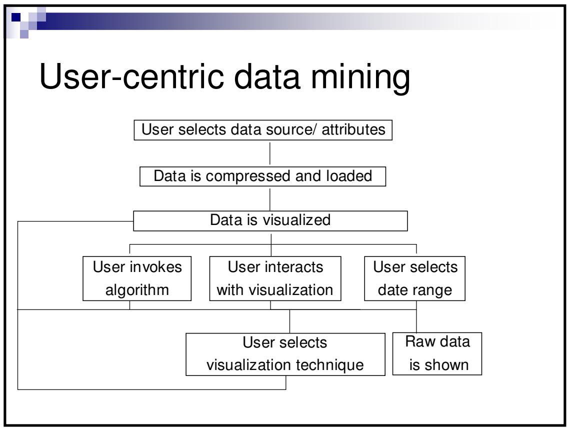


What is Data Mining ?

- **Data mining**, also known as **knowledge-discovery in databases (KDD)**, is the practice of automatically searching large stores of data for patterns.
- data mining uses computational techniques from statistics and pattern recognition.



Architecture



User-centric data mining

User selects data source/ attributes

Data is compressed and loaded

Data is visualized

User invokes algorithm

User interacts with visualization

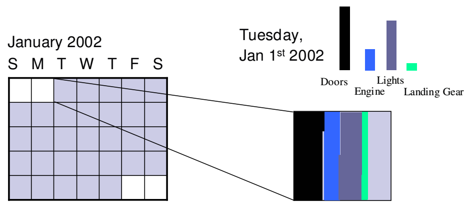
User selects date range

User selects visualization technique

Raw data is shown

The Visualization Component

Time	Event type	Location	…
09/11/2001	Door broken	Seattle	…
09/12/2001	…	…	…



The Visualization Component

- Calendar View
  - □ Visual metaphor: Calendar.
  - □ Structure of data is represented along the event dates is the frequency of events.
  - □ Designed for domain experts – intuitive and versatile design
- If there are few events the visualization is powerful since human's pre-attentive perception is very efficient in looking for variety of patterns

The Temporal Mining Component

- Have algorithms that discover patterns
- Determine which events are involved in the patterns
- Automatically select colors based on the patterns

- Visualize not just data but also patterns
- Use of the same color assignment interface by user and algorithm.

The Visualization Component - interaction

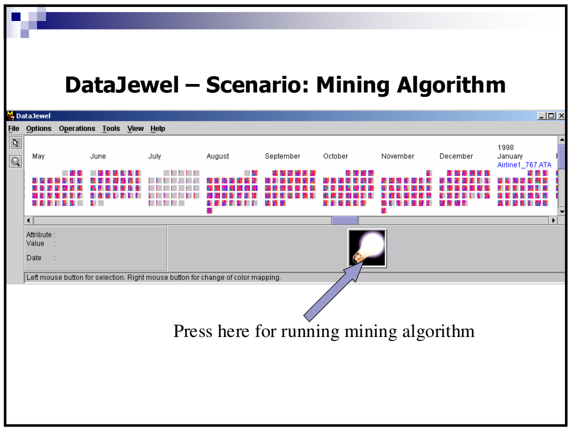
- Selection – subset of dates
- Ascending/descending order frequency
- Interactive color assignment
- Zooming
- Detail on demand

The Database component

- Each event is stored in one record
- Data resides in tables in one or more relational databases
- Aggregate database events according to event date (using select count(*) … group by …)
- Access the raw data of all attributes

The Temporal Mining Component

- Discover one event of one event attribute
  - □ For example - highest variance, most interesting trend - give the event a unique color
- Discover multiple events of one event attribute
  - □ Set of events that together represent a pattern (for example - discovery of similar events) - each event that is part of the pattern receives a distinct color
- Discover one event for each event attribute
  - □ Look for patterns relating event attributes to each other instead of analyzing them separately. (for example – finding similar events across different event attributes) – update the color assignments of each event attribute accordingly.

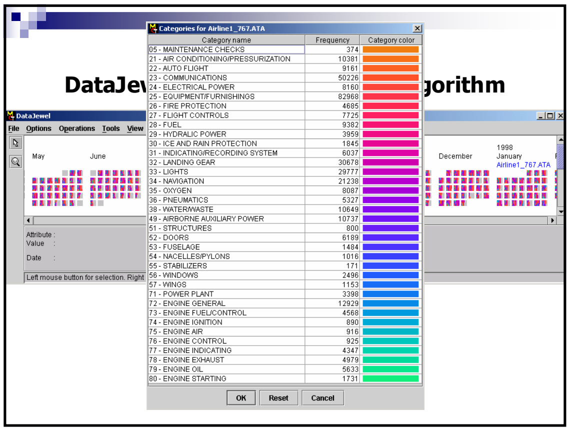


DataJewel – Scenario: Mining Algorithm

DataJewel
File Options Operations Tools View Help
May June July August September October November December 1998 January
Airline1_767.ATA
Attribute :
Value :
Date :

Left mouse button for selection. Right mouse button for change of color mapping.

Press here for running mining algorithm



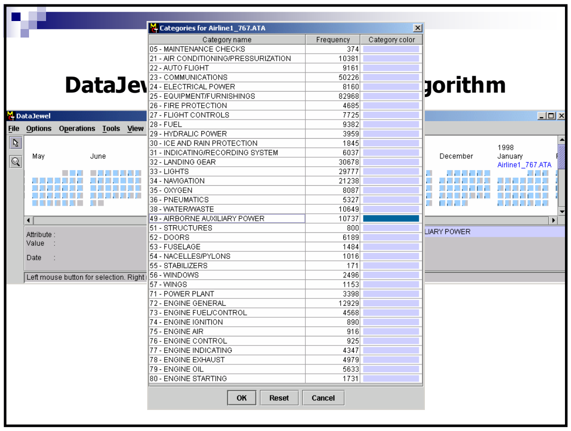
DataJev ... gorithm

DataJewel
File Options Operations Tools View
May June December 1998 January
Airline1_767.ATA
Attribute :
Value :
Date :

Left mouse button for selection. Right

Categories for Airline1_767.ATA

Category name	Frequency	Category color
05 - MAINTENANCE CHECKS	374	■
21 - AIR CONDITIONING/PRESSURIZATION	10381	■
22 - AUTO FLIGHT	9161	■
23 - COMMUNICATIONS	50226	■
24 - ELECTRICAL POWER	8160	■
25 - EQUIPMENT/FURNISHINGS	82968	■
26 - FIRE PROTECTION	4685	■
27 - FLIGHT CONTROLS	7725	■
28 - FUEL	9382	■
29 - HYDRALIC POWER	3959	■
30 - ICE AND RAIN PROTECTION	1845	■
31 - INDICATING/RECORDING SYSTEM	6037	■
32 - LANDING GEAR	30678	■
33 - LIGHTS	29777	■
34 - NAVIGATION	21238	■
35 - OXYGEN	8087	■
36 - PNEUMATICS	5327	■
38 - WATER/WASTE	10649	■
49 - AIRBORNE AUXILIARY POWER	10737	■
51 - STRUCTURES	800	■
52 - DOORS	6189	■
53 - FUSELAGE	1484	■
54 - NACELLES/PYLONS	1016	■
55 - STABILIZERS	171	■
56 - WINDOWS	2496	■
57 - WINGS	1153	■
71 - POWER PLANT	3398	■
72 - ENGINE GENERAL	12929	■
73 - ENGINE FUEL/CONTROL	4568	■
74 - ENGINE IGNITION	890	■
75 - ENGINE AIR	916	■
76 - ENGINE CONTROL	925	■
77 - ENGINE INDICATING	4347	■
78 - ENGINE EXHAUST	4979	■
79 - ENGINE OIL	5633	■
80 - ENGINE STARTING	1731	■



DataJev ... gorithm

DataJewel
File Options Operations Tools View
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LIARY POWER

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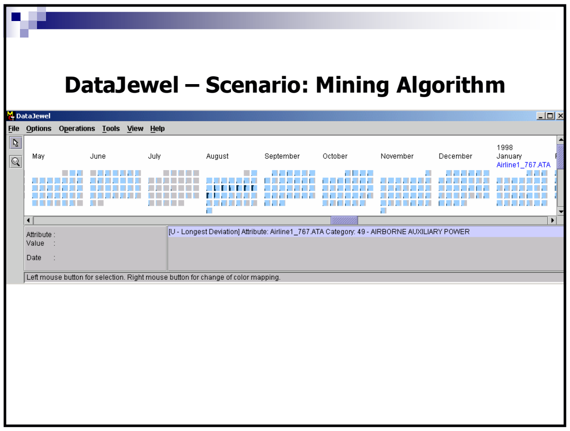
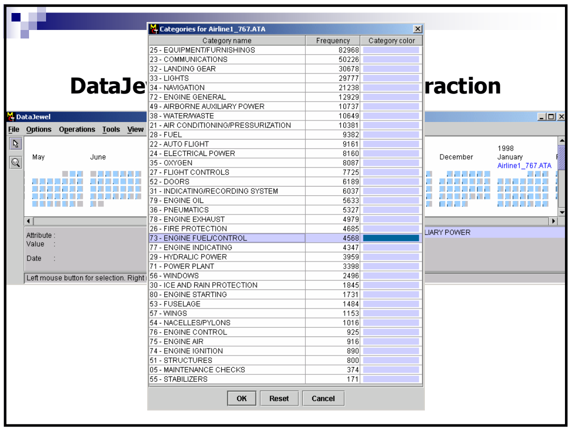


DataJewel – Scenario: Mining Algorithm

DataJewel
File Options Operations Tools View Help
May June July August September October November December 1998 January
Airline1_767.ATA
Attribute :
Value :
Date :

[U - Longest Deviation] Attribute: Airline1_767.ATA Category: 49 - AIRBORNE AUXILIARY POWER

Left mouse button for selection. Right mouse button for change of color mapping.



DataJe ... raction

DataJewel
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LIARY POWER

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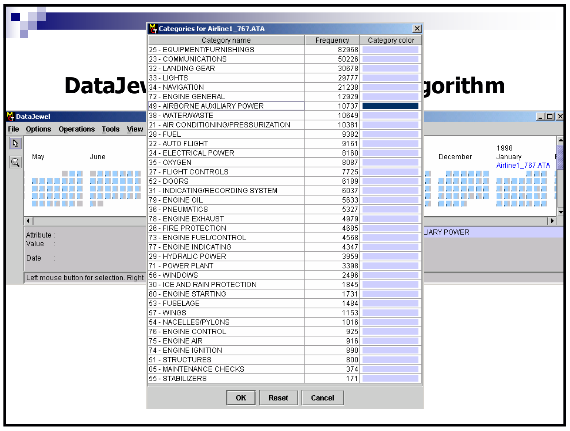

DataJev ... gorithm

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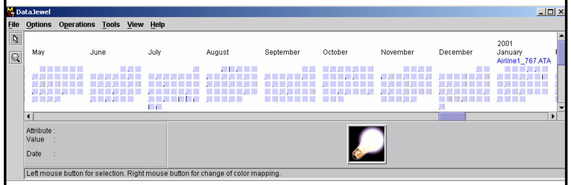
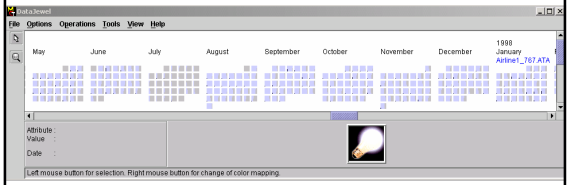
DataJewel – Scenario: User Interaction



Left mouse button for selection. Right mouse button for change of color mapping.

DataJewel – Scenario: User Interaction

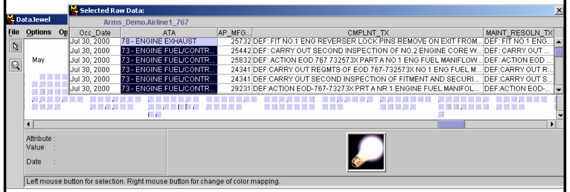


Left mouse button for selection. Right mouse button for change of color mapping.

Critique (+)

- Combine data mining algorithms with visualization
- Can work with several databases
- Scalable – handles large databases
- Intuitive and easy to use – don't need a data mining expert

DataJewel – Scenario: User Interaction



Selected Raw Data:

Arms_Demo.Airline1_767

Occ_Date	ATA	AP_MFG...	CMPLNT_TX	MAINT_RESOLN_TX
Jul 30, 2000	78 - ENGINE EXHAUST	25732	DEF: FIT NO.1 ENG REVERSER LOCK PINS REMOVE ON EXIT FROM...	DEF: FIT NO.1 ENG...
Jul 30, 2000	73 - ENGINE FUEL/CONTR...	25442	DEF: CARRY OUT SECOND INSPECTION OF NO.2 ENGINE CORE W...	DEF: CARRY OUT ...
Jul 30, 2000	73 - ENGINE FUEL/CONTR...	25832	DEF: ACTION EOD 767 732573X PART A NO 1 ENG FUEL MANIFLOW...	DEF: ACTION EOD ...
Jul 30, 2000	73 - ENGINE FUEL/CONTR...	24341	DEF:CARRY OUT REQMTS OF EOD 767-732573X NO 1 ENG FUEL M...	DEF:CARRY OUT R...
Jul 30, 2000	73 - ENGINE FUEL/CONTR...	24341	DEF:CARRY OUT SECOND INSPECTION OF FITMENT AND SECURI...	DEF:CARRY OUT S...
Jul 30, 2000	73 - ENGINE FUEL/CONTR...	29231	DEF:ACTION EOD-767-73273X PRT A NR 1 ENGINE FUEL MANIFOL...	DEF:ACTION EOD-...

Left mouse button for selection. Right mouse button for change of color mapping.

DEVise: Integrated Querying and Visual Exploration of Large Datasets

Miron Livny, Raghu Ramakrishnan, Kevin Beyer, Guangshun Chen, Donko Donjerkovic, Shilpa Lawande, Jussi Myllymaki, and Kent Wenger. Proc. .SIGMOD 1997

Critique (-)

- Hard to see patterns over weeks or months or within a single day
- Only one event attribute for each calendar presentation
- Not easily transferable to other domains like author claims.
- Only for categorical attributes
- Does not handle other types of databases other than relational
- No user studies

Basic concepts

- Mapping each source data record to a visual symbol on screen

TData (Textual Data) – a collection of records with one or more attributes (along with a schema).

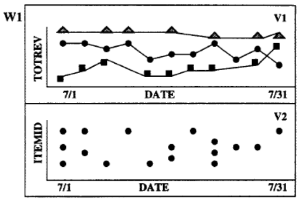
GData (Graphical Data) – high level representation of the screen (x, y, size, color, pattern, orientation, shape

Mapping – a function that is applied to the TData record to produce a GData record.

What is DEVise?

- A data exploration system that allows users to develop, browse, and share visual representations of datasets from several sources.
- A framework which describes a set of querying and visualization primitives that is combined to develop a visual presentation.

Visualization model



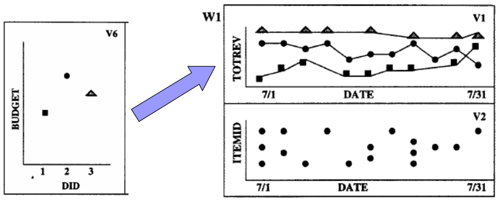
Overall_sales (date, Did, totRev)

Sales (date, itemid, custid, number)

Basic concepts - presentation

- **View** – basic display unit
  - □ TData
  - □ mapping
  - □ Background (title, axes)
  - □ data display
  - □ cursor display – additional data independent information
  - □ visual filter - set of selection (a query) on the GData of a view
- **Window** – collection of views
- **Visual presentation** – collection of windows

Record link example



Some more concepts…

- Cursors – allows the visual filter of one view to be seen as a highlight in another view
- Links – constraints that allows the contents of two views to be coordinated.
  - □ Visual – associate visual filters of two views
  - □ Record – the projection of the data in one view (on the linked attributes) will act as a filter on the TData of the other view
  - □ Operator
  - □ aggregate

Semantics of a visual display

A mapping function is applied from the TData record to produce a Gdata record:

$$< t_1, t_2, \cdots, t_m > \xrightarrow{\sigma_1} g_1$$
$$< t_1, t_2, \cdots, t_m > \xrightarrow{\sigma_2} g_2$$
$$\vdots$$
$$< t_1, t_2, \cdots, t_m > \xrightarrow{\sigma_n} g_n$$

A view can then be represented as: (B, σ^G, μ, T, C)

B – Background

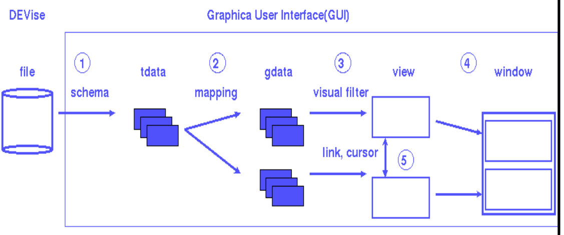
Sigma – visual filter

Mu – mapping

T – TData

C – cursor layer

DEVise Model



Achievements

- Visual presentation capabilities – users can render their data. Simple mapping between data and presentation
- Ability to handle large distributed databases (not limited to available memory)
- Collaborative data analysis
- Support for interactively exploring the data visually at any level of detail

Visual Queries and SQL

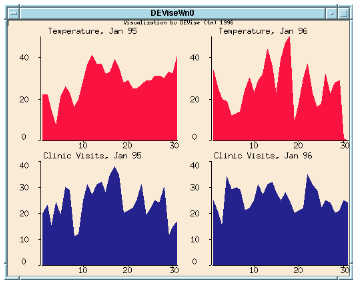
- Visual queries – user selection on visual attributes of a view. (zoom in/out, scroll, point selection)
- Can save and transfer a visual query
- Enables users to generate sophisticated SQL queries through intuitive graphical operations
- Can be used as an SQL front-end (but not only!)

Another Example:

- Input data: has information about deposits into various accounts at 2 different banks:
  - □ Account (bankNum, SSN, accNum, pic, …)
  - □ Deposit (accNum, date, amount)
- problem: We want to analyze the transactions to find out who has a suspiciously large number of transactions within a short period of time.

Example

Input two data sources: clinic information about number of visits, and information about temperature



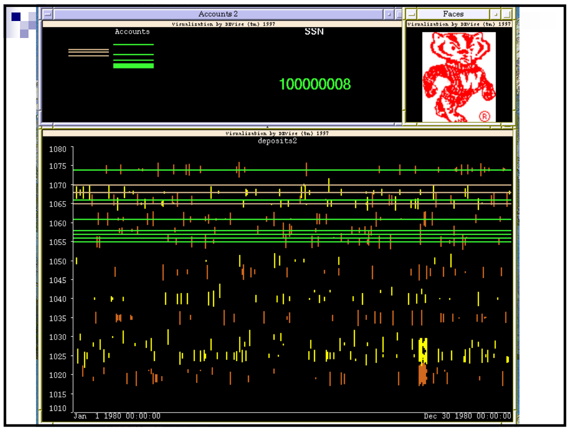
critique

+

- □ Very thorough well-defined framework
- □ Many examples of implementations in real application

-

- □ Leaves the visualization decisions to the user (but that's the idea…)
- □ Some visualizations are very hard or impossible to do



Questions?