COURSE NAME:
DATA WAREHOUSING & DATA MINING

LECTURE 22
TOPICS TO BE COVERED:

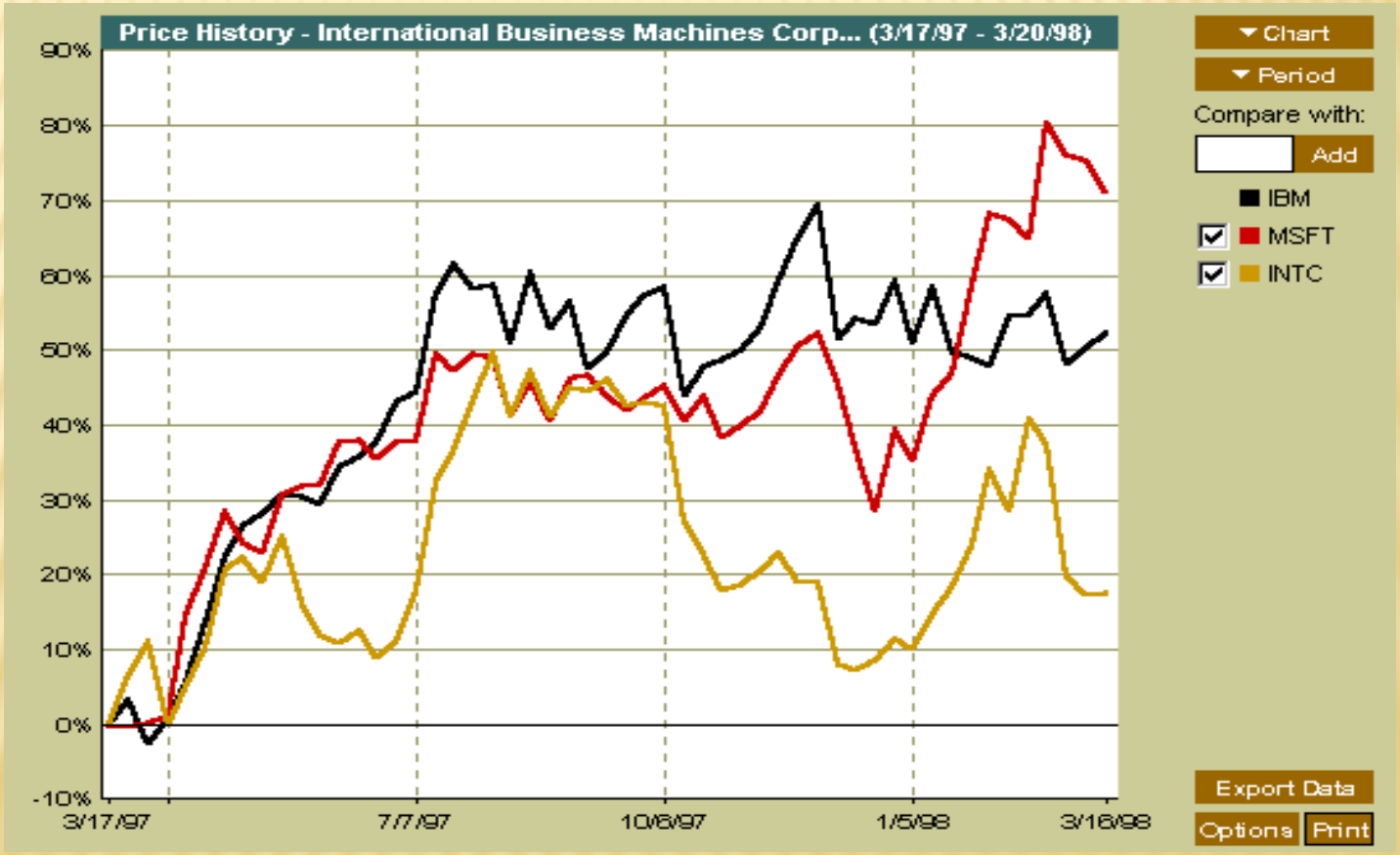
- Time series data
- Sequence data mining

MINING TIME-SERIES AND SEQUENCE DATA

- Time-series database
  - Consists of sequences of values or events changing with time
  - Data is recorded at regular intervals
  - Characteristic time-series components
    - Trend, cycle, seasonal, irregular
- Applications
  - Financial: stock price, inflation
  - Biomedical: blood pressure
  - Meteorological: precipitation

MINING TIME-SERIES AND SEQUENCE DATA

Time-series plot



MINING TIME-SERIES AND SEQUENCE DATA: TREND ANALYSIS

- A time series can be illustrated as a time-series graph which describes a point moving with the passage of time
- Categories of Time-Series Movements
  - Long-term or trend movements (trend curve)
  - Cyclic movements or cycle variations, e.g., business cycles
  - Seasonal movements or seasonal variations
    - i.e, almost identical patterns that a time series appears to follow during corresponding months of successive years.
  - Irregular or random movements

ESTIMATION OF TREND CURVE

- The freehand method
  - Fit the curve by looking at the graph
  - Costly and barely reliable for large-scaled data mining
- The least-square method
  - Find the curve minimizing the sum of the squares of the deviation of points on the curve from the corresponding data points
- The moving-average method
  - Eliminate cyclic, seasonal and irregular patterns
  - Loss of end data
  - Sensitive to outliers

DISCOVERY OF TREND IN TIME-SERIES (1)

- Estimation of seasonal variations
  - Seasonal index
    - Set of numbers showing the relative values of a variable during the months of the year
    - E.g., if the sales during October, November, and December are 80%, 120%, and 140% of the average monthly sales for the whole year, respectively, then 80, 120, and 140 are seasonal index numbers for these months
  - Deseasonalized data
    - Data adjusted for seasonal variations
    - E.g., divide the original monthly data by the seasonal index numbers for the corresponding months

DISCOVERY OF TREND IN TIME-SERIES (2)

- Estimation of cyclic variations
  - If (approximate) periodicity of cycles occurs, cyclic index can be constructed in much the same manner as seasonal indexes
- Estimation of irregular variations
  - By adjusting the data for trend, seasonal and cyclic variations
- With the systematic analysis of the trend, cyclic, seasonal, and irregular components, it is possible to make long- or short-term predictions with reasonable quality

SIMILARITY SEARCH IN TIME-SERIES ANALYSIS

- Normal database query finds exact match
- Similarity search finds data sequences that differ only slightly from the given query sequence
- Two categories of similarity queries
  - Whole Sequence Matching : find a sequence that is similar to the query sequence
  - Subsequence matching: find all pairs of similar sequences
- Typical Applications
  - Financial market
  - Market basket data analysis
  - Scientific databases
  - Medical diagnosis

ENHANCED SIMILARITY SEARCH METHODS

- Allow for gaps within a sequence or differences in offsets or amplitudes
- Normalize sequences with amplitude scaling and offset translation
- Two subsequences are considered similar if one lies within an envelope of ε width around the other, ignoring outliers
- Two sequences are said to be similar if they have enough non-overlapping time-ordered pairs of similar subsequences
- Parameters specified by a user or expert: sliding window size, width of an envelope for similarity, maximum gap, and matching fraction

QUERY LANGUAGES FOR TIME SEQUENCES

- Time-sequence query language
  - Should be able to specify sophisticated queries like

    Find all of the sequences that are similar to some sequence in class *A*, but not similar to any sequence in class *B*
  - Should be able to support various kinds of queries: range queries, all-pair queries, and nearest neighbor queries
- Shape definition language
  - Allows users to define and query the overall shape of time sequences
  - Uses human readable series of sequence transitions or macros
  - Ignores the specific details
    - E.g., the pattern up, Up, UP can be used to describe increasing degrees of rising slopes
    - Macros: spike, valley, etc.

SEQUENTIAL PATTERN MINING

- Mining of frequently occurring patterns related to time or other sequences
- Sequential pattern mining usually concentrate on symbolic patterns
- Examples
  - Renting “Star Wars”, then “Empire Strikes Back”, then “Return of the Jedi” in that order
  - Collection of ordered events within an interval
- Applications
  - Targeted marketing
  - Customer retention
  - Weather prediction

MINING SEQUENCES (CONT.)

Customer-sequence

CustId	Video sequence
1	{(C), (H)}
2	{(AB), (C), (DFG)}
3	{(CEG)}
4	{(C), (DG), (H)}
5	{(H)}

Map Large Itemsets

Large Itemsets	MappedID
(C)	1
(D)	2
(G)	3
(DG)	4
(H)	5

Sequential patterns with support > 0.25

{(C), (H)}

{(C), (DG)}

PERIODICITY ANALYSIS

- Periodicity is everywhere: tides, seasons, daily power consumption, etc.
- Full periodicity
  - Every point in time contributes (precisely or approximately) to the periodicity
- Partial periodicity: A more general notion
  - Only some segments contribute to the periodicity
    - Jim reads NY Times 7:00-7:30 am every week day
- Cyclic association rules
  - Associations which form cycles
- Methods
  - Full periodicity: FFT, other statistical analysis methods
  - Partial and cyclic periodicity: Variations of Apriori-like mining methods