

Data Analytics-Introduction

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Introduction

- Motivation: Why data mining?
- What is data mining?
- Data Mining: On what kind of data?
- Data mining functionality
- Are all the patterns interesting?
- Classification of data mining systems
- Major issues in data mining

- Data explosion problem
 - Automated data collection tools and mature database technology lead to tremendous amounts of data stored in databases, data warehouses and other information repositories
- We are drowning in data, but starving for knowledge!
- Solution: Data warehousing and data mining
 - Data warehousing and on-line analytical processing
 - Extraction of interesting knowledge (rules, regularities, patterns, constraints) from data in large databases

Evolution of Database Technology

- 1960s:
 - Data collection, database creation, IMS and network DBMS
- 1970s:
 - Relational data model, relational DBMS implementation
- 1980s:
 - RDBMS, advanced data models (extended-relational, OO, deductive, etc.) and application-oriented DBMS (spatial, scientific, engineering, etc.)
- 1990s—2000s:
 - Data mining and data warehousing, multimedia databases, and Web databases

What Is Data Mining?

- Data mining (knowledge discovery in databases):
 - Extraction of interesting information or patterns from data in large databases
 - Knowledge discovery(mining) in databases (KDD), knowledge extraction, data/pattern analysis, data archeology, information harvesting, business intelligence, etc.

Why Data Mining? — Potential Applications

- Database analysis and decision support
 - Market analysis and management
 - target marketing, customer relation management, market basket analysis, cross selling, market segmentation
 - Risk analysis and management
 - Forecasting, customer retention, improved underwriting, quality control, competitive analysis
 - Fraud detection and management
- Other Applications
 - Text mining (news group, email, documents) and Web analysis.
 - Intelligent query answering

Market Analysis and Management (1)

- Where are the data sources for analysis?
 - Credit card transactions, loyalty cards, discount coupons, customer complaint calls, plus (public) lifestyle studies
- Target marketing
 - Find clusters of “model” customers who share the same characteristics: interest, income level, spending habits, etc.
- Determine customer purchasing patterns over time
 - Conversion of single to a joint bank account: marriage, etc.
- Cross-market analysis
 - Associations/co-relations between product sales
 - Prediction based on the association information

Market Analysis and Management (2)

- Customer profiling
 - data mining can tell you what types of customers buy what products (clustering or classification)
- Identifying customer requirements
 - identifying the best products for different customers
 - use prediction to find what factors will attract new customers
- Provides summary information
 - various multidimensional summary reports
 - statistical summary information (data central tendency and variation)

Corporate Analysis and Risk Management

- Finance planning and asset evaluation
 - cash flow analysis and prediction
 - cross-sectional and time series analysis (financial-ratio, trend analysis, etc.)
- Resource planning:
 - summarize and compare the resources and spending
- Competition:
 - monitor competitors and market directions
 - group customers into classes and a class-based pricing procedure
 - set pricing strategy in a highly competitive market

Fraud Detection and Management (1)

- Applications
 - widely used in health care, retail, credit card services, telecommunications (phone card fraud), etc.
- Approach
 - use historical data to build models of fraudulent behavior and use data mining to help identify similar instances
- Examples
 - auto insurance: detect a group of people who stage accidents to collect on insurance
 - money laundering: detect suspicious money transactions (US Treasury's Financial Crimes Enforcement Network)
 - medical insurance: detect professional patients and ring of doctors and ring of references

Fraud Detection and Management (2)

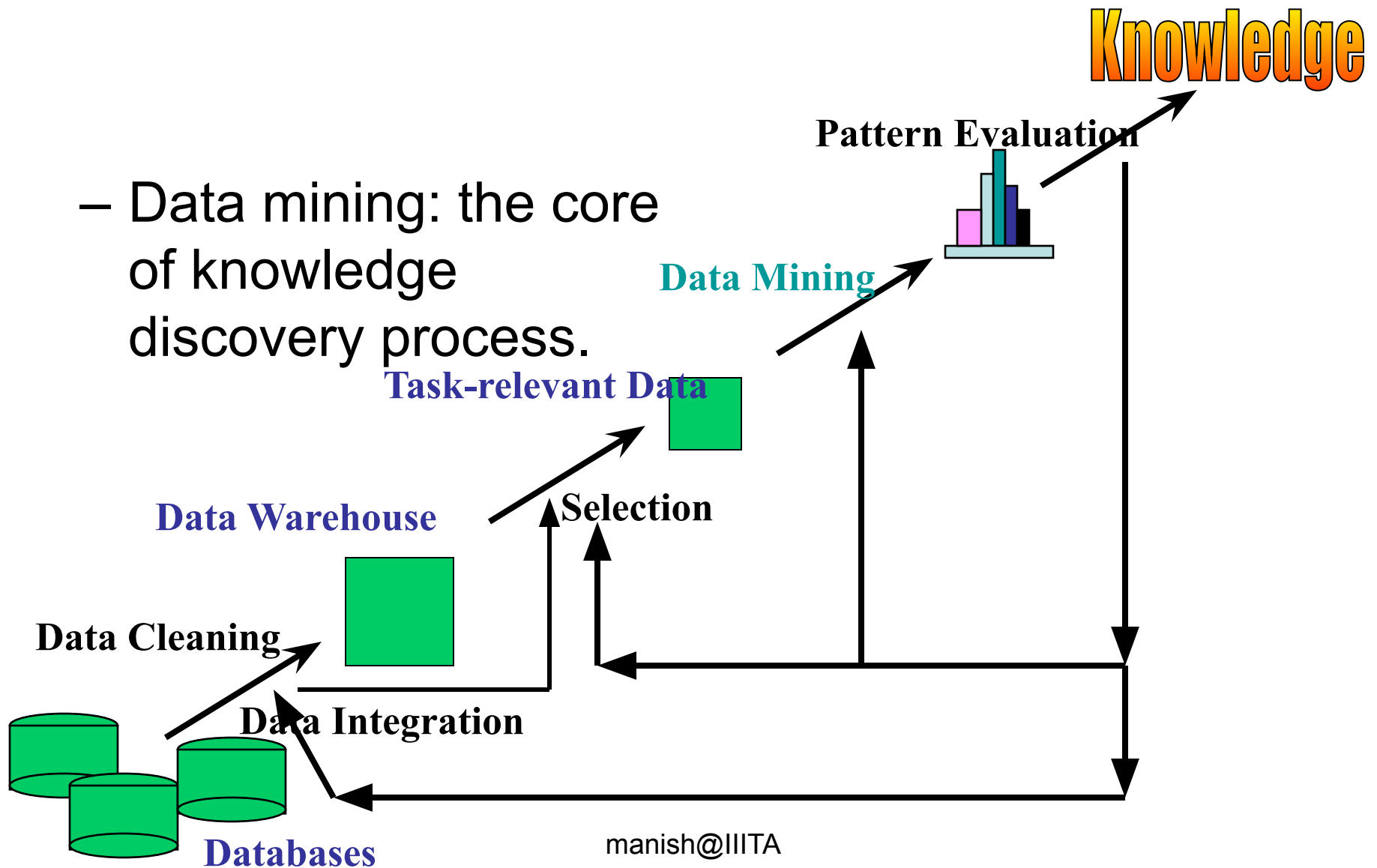
- Detecting inappropriate medical treatment
 - Australian Health Insurance Commission identifies that in many cases blanket screening tests were requested (save Australian \$1m/yr).
- Detecting telephone fraud
 - Telephone call model: destination of the call, duration, time of day or week. Analyze patterns that deviate from an expected norm.
 - British Telecom identified discrete groups of callers with frequent intra-group calls, especially mobile phones, and broke a multimillion dollar fraud.
- Retail
 - Analysts estimate that 38% of retail shrink is due to dishonest employees.

Other Applications

- Sports
 - IBM Advanced Scout analyzed NBA game statistics (shots blocked, assists, and fouls) to gain competitive advantage for New York Knicks and Miami Heat
- Astronomy
 - JPL and the Palomar Observatory discovered 22 quasars with the help of data mining
- Internet Web Surf-Aid
 - IBM Surf-Aid applies data mining algorithms to Web access logs for market-related pages to discover customer preference and behavior pages, analyzing effectiveness of Web marketing, improving Web site organization, etc.

Data Mining: A KDD Process

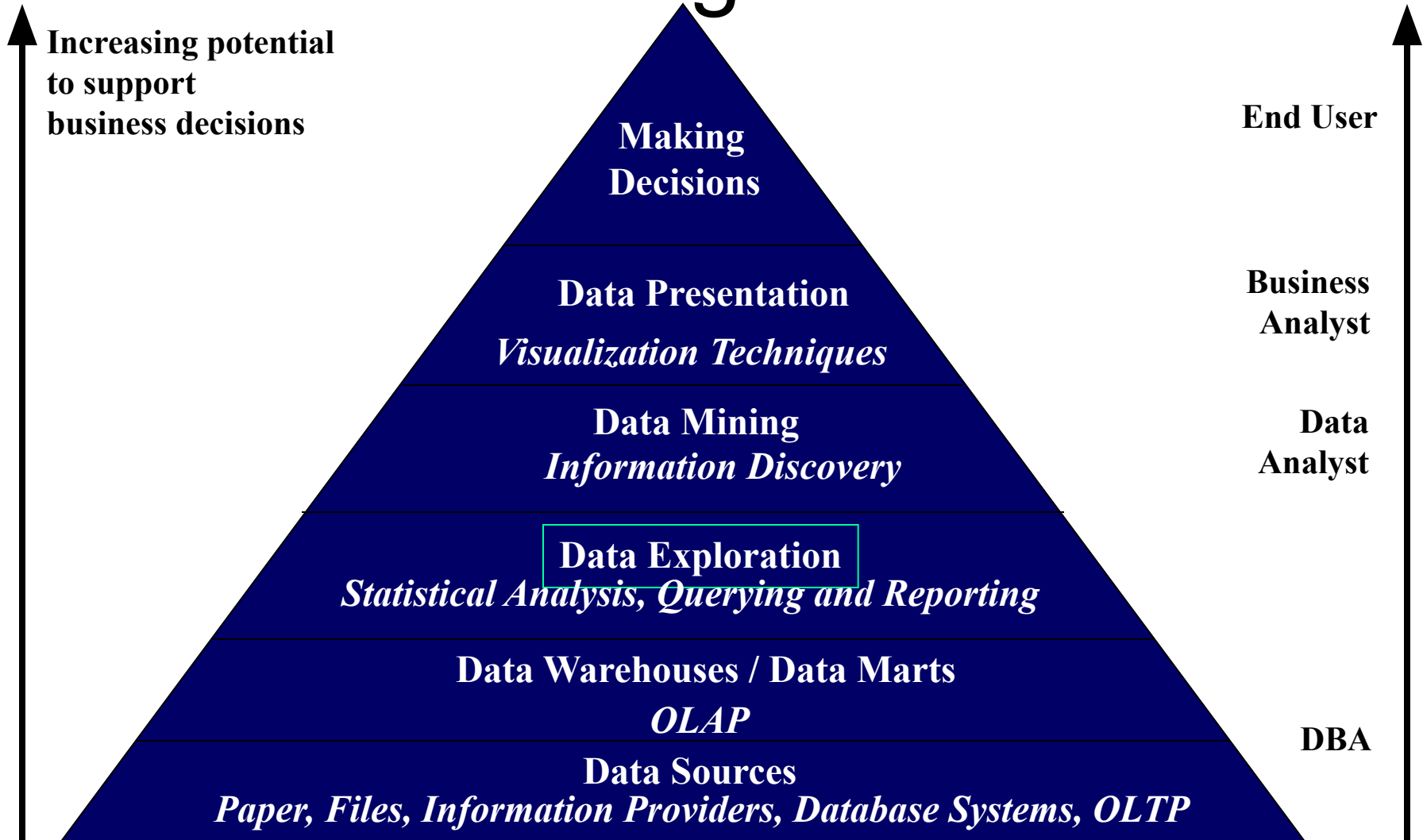
- Data mining: the core of knowledge discovery process.



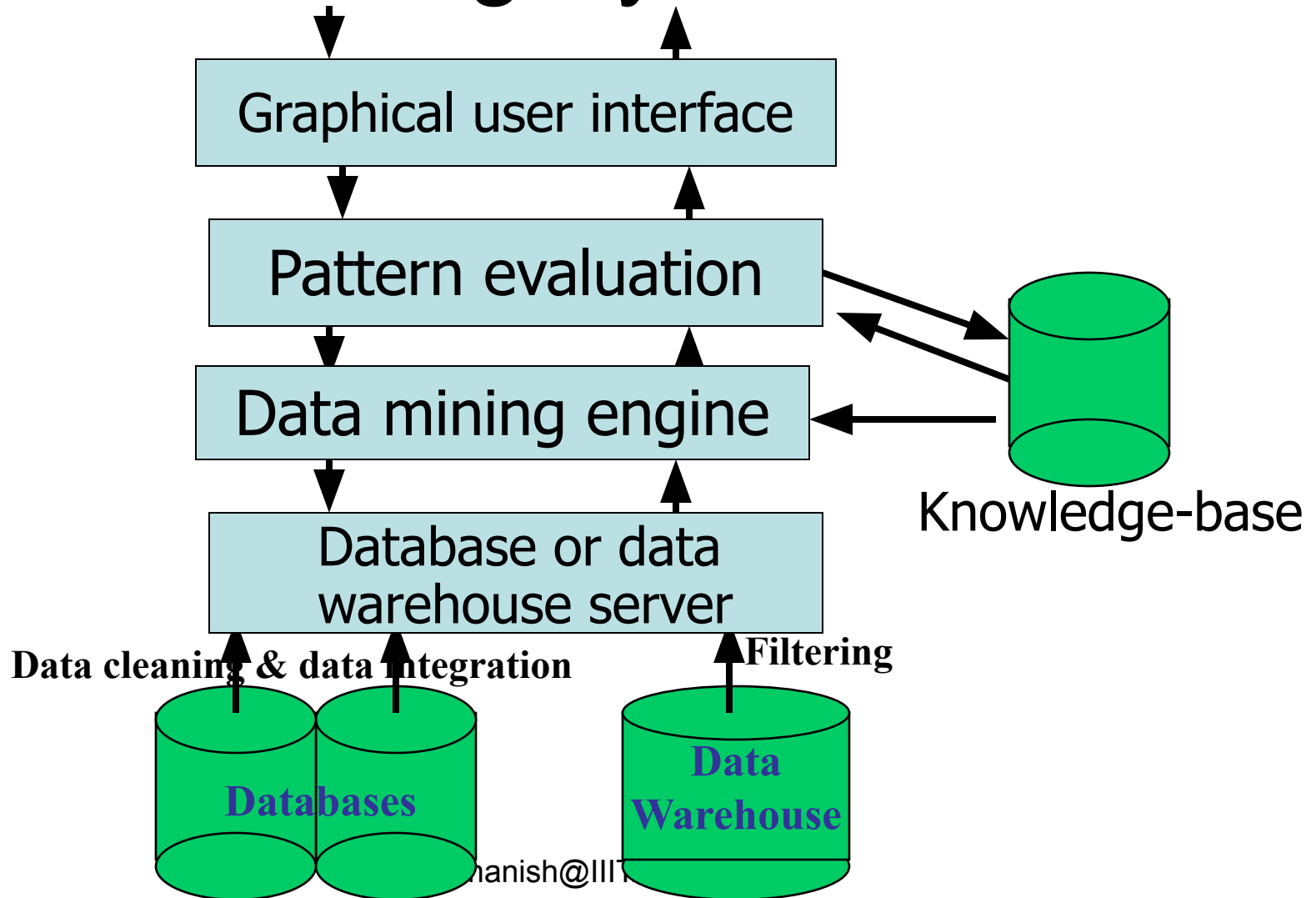
Steps of a KDD Process

- Learning the application domain:
 - relevant prior knowledge and goals of application
- Creating a target data set: data selection
- Data cleaning and preprocessing: (may take 60% of effort!)
- Data reduction and transformation:
 - Find useful features, dimensionality/variable reduction, invariant representation.
- Choosing functions of data mining
 - summarization, classification, regression, association, clustering.
- Choosing the mining algorithm(s)
- Data mining: search for patterns of interest
- Pattern evaluation and knowledge presentation
 - visualization, transformation, removing redundant patterns, etc.
- Use of discovered knowledge

Data Mining and Business Intelligence



Architecture of a Typical Data Mining System



Data Mining: On What Kind of Data?

- Relational databases
- Data warehouses
- Transactional databases
- Advanced DB and information repositories
 - Object-oriented and object-relational databases
 - Spatial databases
 - Time-series data and temporal data
 - Text databases and multimedia databases
 - Heterogeneous databases
 - WWW

Data Mining Functionalities (1)

- Concept description: Characterization and discrimination
 - Generalize, summarize, and contrast data characteristics, e.g., dry vs. wet regions
- Association (correlation and causality)
 - Multi-dimensional vs. single-dimensional association
 - $\text{age}(X, \text{"20..29"}) \wedge \text{income}(X, \text{"20..29K"}) \rightarrow \text{buys}(X, \text{"PC"})$

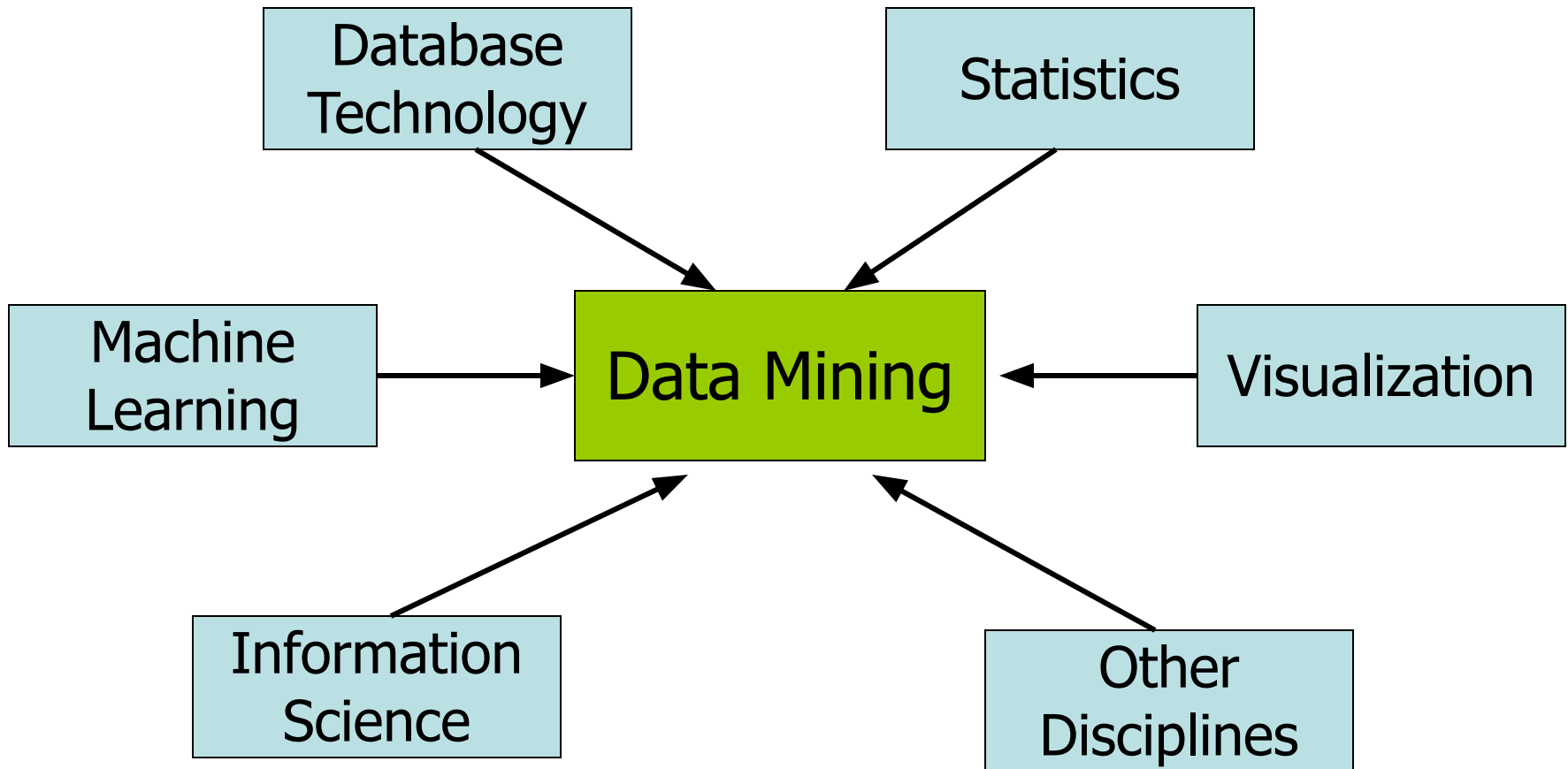
Data Mining Functionalities (2)

- Classification and Prediction
 - Finding models (functions) that describe and distinguish classes or concepts for future prediction
 - E.g., classify countries based on climate, or classify cars based on mileage
 - Presentation: decision-tree, classification rule
 - Prediction: Predict some unknown or missing numerical values
- Cluster analysis
 - Class label is unknown: Group data to form new classes, e.g., cluster houses to find distribution patterns

Data Mining Functionalities (3)

- Trend and evolution analysis
 - Trend and deviation: regression analysis
 - Sequential pattern mining, periodicity analysis
 - Similarity-based analysis

Data Mining: Confluence of Multiple Disciplines



Data Mining: Classification Schemes

- General functionality
 - Descriptive data mining
 - Predictive data mining
- Different views, different classifications
 - Kinds of databases to be mined
 - Kinds of knowledge to be discovered
 - Kinds of techniques utilized
 - Kinds of applications adapted

A Multi-Dimensional View of Data Mining Classification

- **Databases to be mined**
 - Relational, transactional, object-oriented, object-relational, active, spatial, time-series, text, multi-media, heterogeneous, legacy, WWW, etc.
- **Knowledge to be mined**
 - Characterization, discrimination, association, classification, clustering, trend etc.
 - Multiple/integrated functions and mining at multiple levels
- **Techniques utilized**
 - Database-oriented, data warehouse (OLAP), machine learning, statistics
- **Applications adapted**
 - Retail, telecommunication, banking, fraud analysis, DNA mining, stock market analysis, Web mining etc.

Major Issues in Data Mining (1)

- Mining methodology and user interaction
 - Mining different kinds of knowledge in databases
 - Interactive mining of knowledge at multiple levels of abstraction
 - Incorporation of background knowledge
 - Data mining query languages and ad-hoc data mining
 - Expression and visualization of data mining results
 - Handling noise and incomplete data
 - Pattern evaluation: the interestingness problem
- Performance and scalability
 - Efficiency and scalability of data mining algorithms
 - Parallel, distributed and incremental mining methods

Major Issues in Data Mining (2)

- Issues relating to the diversity of data types
 - Handling relational and complex types of data
 - Mining information from heterogeneous databases and global information systems (WWW)
 - Application of discovered knowledge
 - Domain-specific data mining tools
 - Intelligent query answering
 - Process control and decision making
 - Integration of the discovered knowledge with existing knowledge: A knowledge fusion problem
 - Protection of data security, integrity, and privacy

Summary

- Data mining: discovering interesting patterns from large amounts of data
- A natural evolution of database technology, in great demand, with wide applications
- A KDD process includes data cleaning, data integration, data selection, transformation, data mining, pattern evaluation, and knowledge presentation
- Mining can be performed in a variety of information repositories
- Data mining functionalities: characterization, discrimination, association, classification, clustering, outlier and trend analysis, etc.
- Classification of data mining systems
- Major issues in data mining