## Chapter 1: Introduction to Data Mining

## **CSE 435:Data Mining**



#### Md. Atikuzzaman Lecturer

Department of Computer Science & Engineering Green University of Bangladesh atik@cse.green.edu.bd

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## What Is Data Mining?

The Modern Data Landscape

We live in a world where vast amounts of data are generated constantly and rapidly.

Definition (Data Mining)

Data mining is the process of discovering interesting patterns and knowledge in large data sets.

#### A More Accurate Term

The term "Data mining" is often considered a misnomer. A more fitting name would be "knowledge mining from data". Other terms include KDD (Knowledge Discovery from Data) and data analytics.

## Example: Turning Data into Knowledge

### Google Flu Trends

- Google found a close relationship between the number of people who search for flu-related information and the number of people who actually have flu symptoms.
- This allowed them to estimate flu activity up to two weeks faster than traditional systems.

Data mining is a young, dynamic, and promising field.

# Data Mining: A Step in Knowledge Discovery

Data mining is an essential step in the Knowledge Discovery from Data (KDD) process.

- Data cleaning: Remove noise and inconsistencies.
- ② Data integration: Combine multiple data sources.
- 3 Data selection: Retrieve relevant data.
- Data transformation: Convert data into a suitable format.
- **Data mining**: Apply intelligent methods to extract patterns.
- Pattern evaluation: Identify truly interesting patterns.
- Knowledge presentation: Visualize and present the knowledge.

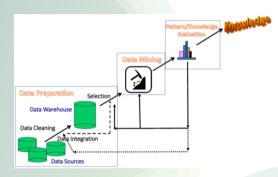


Figure: The Knowledge Discovery Process

# Data Types for Mining (Slide 1 of 2)

#### Structured Data

Has a uniform, table-like structure with a fixed set of attributes. Often found in relational databases and data warehouses.

#### Semi-structured Data

Allows for more flexible or nested structures. Examples include transactional data, sequence data (like time-series or weblogs), and graph or network data.

# Data Types for Mining (Slide 2 of 2)

#### **Unstructured Data**

Includes text data and multimedia content such as audio, images, and video.

#### Real-World Data

Data in the real world is often a complex mixture of these different types.

### Streaming Data

Data can also arrive as a continuous, dynamic stream (e.g., from video surveillance), which poses challenges for real-time analysis.

#### Multidimensional Data Summarization

This involves generalizing, summarizing, and contrasting data characteristics, often using data cube technology.

- Utilizes Online Analytical Processing (OLAP).
- Requires scalable methods for computing multidimensional aggregates efficiently.



Figure: A data cube for multidimensional analysis.

## Frequent Patterns and Associations

This task finds items that frequently co-occur in your data.

### Typical Association Rule

An example rule from market basket analysis could be:

$$\mathsf{Diaper} \to \mathsf{Beer} \; [\mathsf{support} = 0.5\%, \mathsf{confidence} = 75\%]$$

This suggests that customers who buy diapers often buy beer as well.

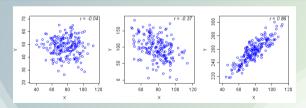


Figure: Scatter plots showing different correlations.

# Classification and Regression (Slide 1 of 2)

### Definition (Predictive Analysis)

Classification and regression are forms of predictive analysis. They build models from training data to predict unknown class labels or continuous values.

#### Common Methods

- Decision trees
- Naïve Bayesian classification
- Support vector machines (SVM)
- Neural networks
- Logistic regression

# Classification and Regression (Slide 2 of 2)

## Typical Applications

- Credit card fraud detection
- Direct marketing campaign targeting
- Classifying medical diseases
- Spam email filtering

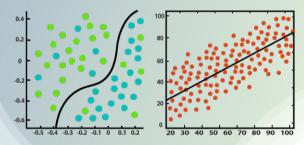


Figure: Regression vs Classification

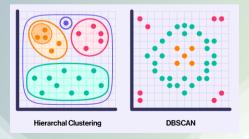
## Cluster Analysis

### Definition (Unsupervised Learning)

Cluster analysis groups data to form new categories (clusters) without any prior knowledge of class labels.

### Core Principle

Maximize the similarity of objects within the same class and minimize the similarity between objects in different classes.



## Deep Learning

A rapidly expanding field that uses various neural network architectures (CNNs, RNNs, Transformers) for tasks like classification, clustering, and outlier detection.

#### It has broad applications in:

- Computer vision
- Natural language processing
- Social network analysis
- Bioinformatics

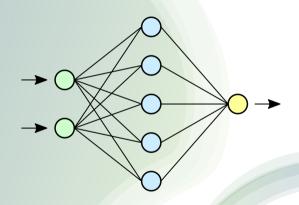


Figure: A neural network architecture.

## Outlier Analysis

## Definition (Outlier)

An outlier is a data object that deviates significantly from the general behavior of the data. It can be noise or a valuable discovery.

### **Applications**

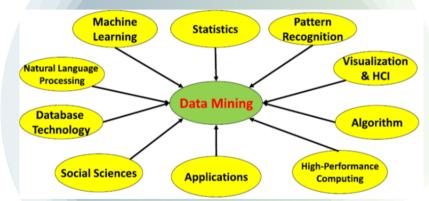
Outlier analysis is highly useful in fraud detection, network intrusion detection, and the analysis of rare events.

One person's noise could be another's treasure.



# Data Mining: An Interdisciplinary Field

Data mining is a confluence of multiple disciplines, drawing from statistics, machine learning, database systems, and visualization.



This interdisciplinary nature is necessary to handle the scale, high-dimensionality, and complexity of modern data.

## **Data Mining Applications**

- Web page analysis, ranking, and recommender systems.
- Market basket analysis for targeted marketing.
- Biological and medical data analysis.
- Software engineering and text analysis.
- Social and information network analysis.

## Major Tools and Systems

SAS, Microsoft SQL Server Analysis Manager, Oracle Data Mining Tools.

# Data Mining and Society

#### **Benefits**

Data mining can help scientific discovery, improve business management, and enhance security (e.g., cyberattack discovery).

#### Risks and Concerns

We must guard against the misuse of data mining, as it poses risks of unintentionally disclosing confidential business or personal information.

#### The Path Forward

The goal is to preserve data security and privacy while still performing successful data mining. Research in **privacy-preserving data mining** is a crucial, ongoing theme.

## **Chapter Summary**

- Data mining is the process of discovering interesting knowledge from massive amounts of data.
- It is a crucial step in the KDD process, which also includes data preparation and knowledge presentation.
- Key functionalities include summarization, classification, clustering, deep learning, and outlier analysis.
- It is a confluence of multiple disciplines and has broad applications across many industries.
- It is important to promote secure and ethical data mining practices to benefit society while protecting privacy.

### References

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