COMP9318: Data Warehousing and Data Mining

Chapter 1. Introduction

- Motivation: Why data mining?
- What is data mining?
- Data Mining: O
- Data mining fu
- Are all the patterns interestin
- Classification of data mining systems
- Major issues in data mining

Necessity Is the Mother of Invention

- Data explosion problem
  - Automated data collection tools and mature database technology lead to tremendous amounts of data accumulated and/or to be analyzed in databases, data tion repositories
- We are drowning in e!

Who could be expected to digest th rds) each having tens or hundreds of fields?

- Solution: Data warehousing and data mining
  - Data warehousing and on-line analytical processing
  - Mining 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, advance[illegible]onal, OO, deductive, etc.)
  - Application-oriented DBMS (spatial[illegible]eering, etc.)
- 1990s:
  - Data mining, data warehousing, multimedia databases, and Web databases
- 2000s
  - Stream data management and mining
  - Data mining with a variety of applications
  - Web technology and global information systems

What Is Data Mining?

- Data mining (knowledge discovery from data)
  - Extraction of interesting (non-trivial, implicit, previously unknown and potentially useful) patterns or knowledge from huge amount of data
  - Data mining: a
- Alternative nam
  - Knowledge discovery (mining) in DD), knowledge extraction, data/pattern analysis, data archeology, data dredging, information harvesting, business intelligence, etc.
- Watch out: Is everything "data mining"?
  - (Deductive) query processing.
  - Expert systems or small ML/statistical programs

Why Data Mining?—Potential Applications

- Data analysis and decision support
  - Market analysis and management
    - Target marketing, customer relationship management (CRM), market basket analysis, cross selling, market segmentation
  - Risk analysis an
    - Forecasting, customer retent underwriting, quality control, competitive a
  - Fraud detection and detection of unusual patterns (outliers)
- Other Applications
  - Text mining (news group, email, documents) and Web mining
  - Stream data mining
  - DNA and bio-data analysis

Market Analysis and Management

- Where does the data come from?
  - 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
- Cross-market analysis
  - Associations/co-relations between product sale ed on such association
- Customer profiling
  - What types of customers buy what products (clustering or classification)
- Customer requirement analysis
  - identifying the best products for different customers
  - predict what factors will attract new customers
- Provision of summary information
  - multidimensional summary reports
  - statistical summary information (data central tendency and variation)

Corporate Analysis & Risk Management

- Finance planning and asset evaluation
  - cash flow analysis and prediction
  - contingent claim analysis to evaluate assets
  - cross-sectional and time series analysis (financial-ratio, trend analysis, etc.)
- Resource plann
  - summarize and compare the res enuing
- 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 & Mining Unusual Patterns

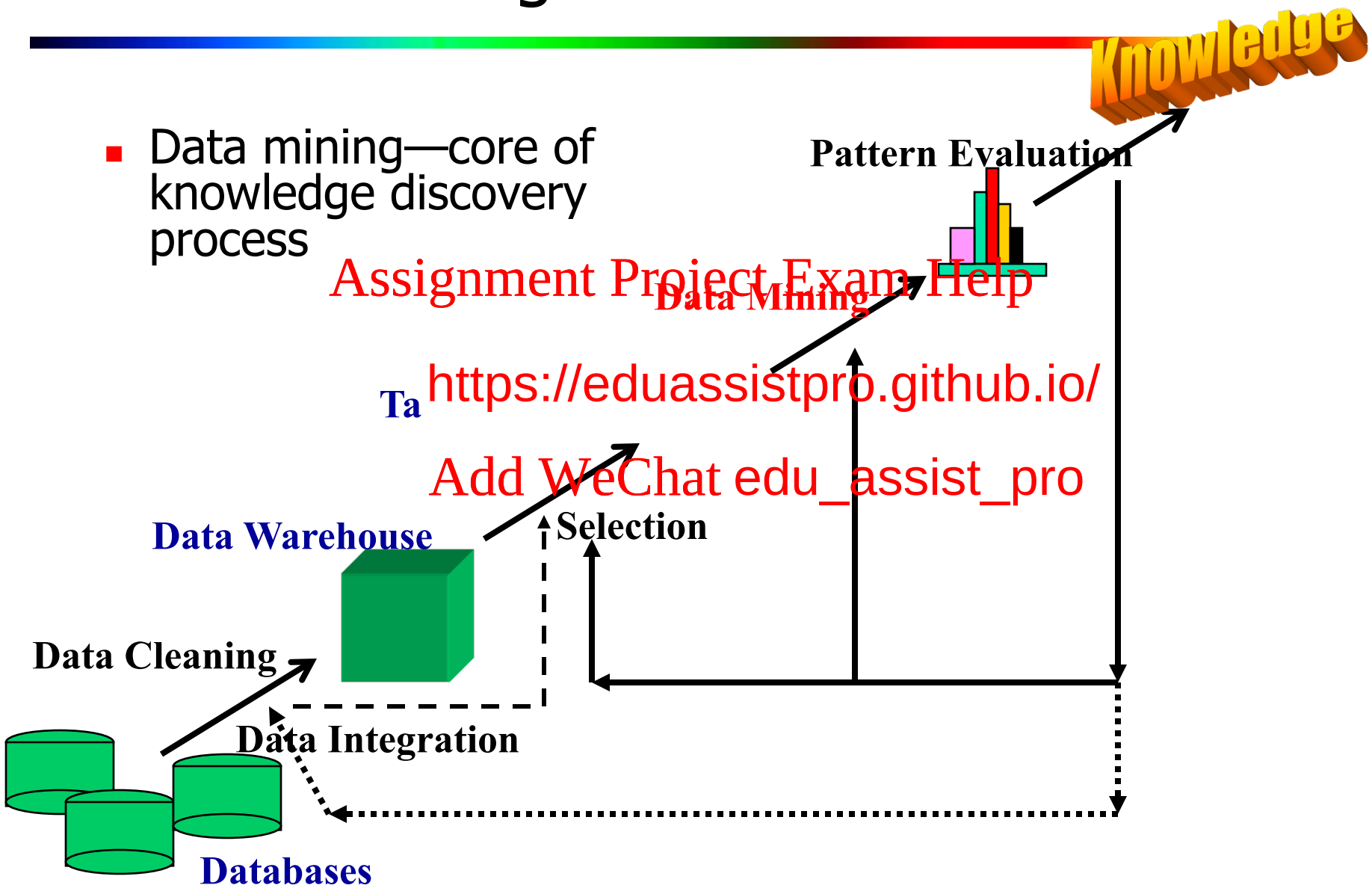
- Approaches: Clustering & model construction for frauds, outlier analysis
- Applications: Health care, retail, credit card service, telecomm.
  - Auto insurance: ring of collisions
  - Money laundering: suspicious monetary transactions
  - Medical insurance
    - Professional p[illegible]g of references
    - Unnecessary or correlated screen
  - Telecommunications: phone-call frau
    - Phone call model: destination of the call, duration, time of day or week. Analyze patterns that deviate from an expected norm
  - Retail industry
    - Analysts estimate that 38% of retail shrink is due to dishonest employees
  - Anti-terrorism

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 Observato 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

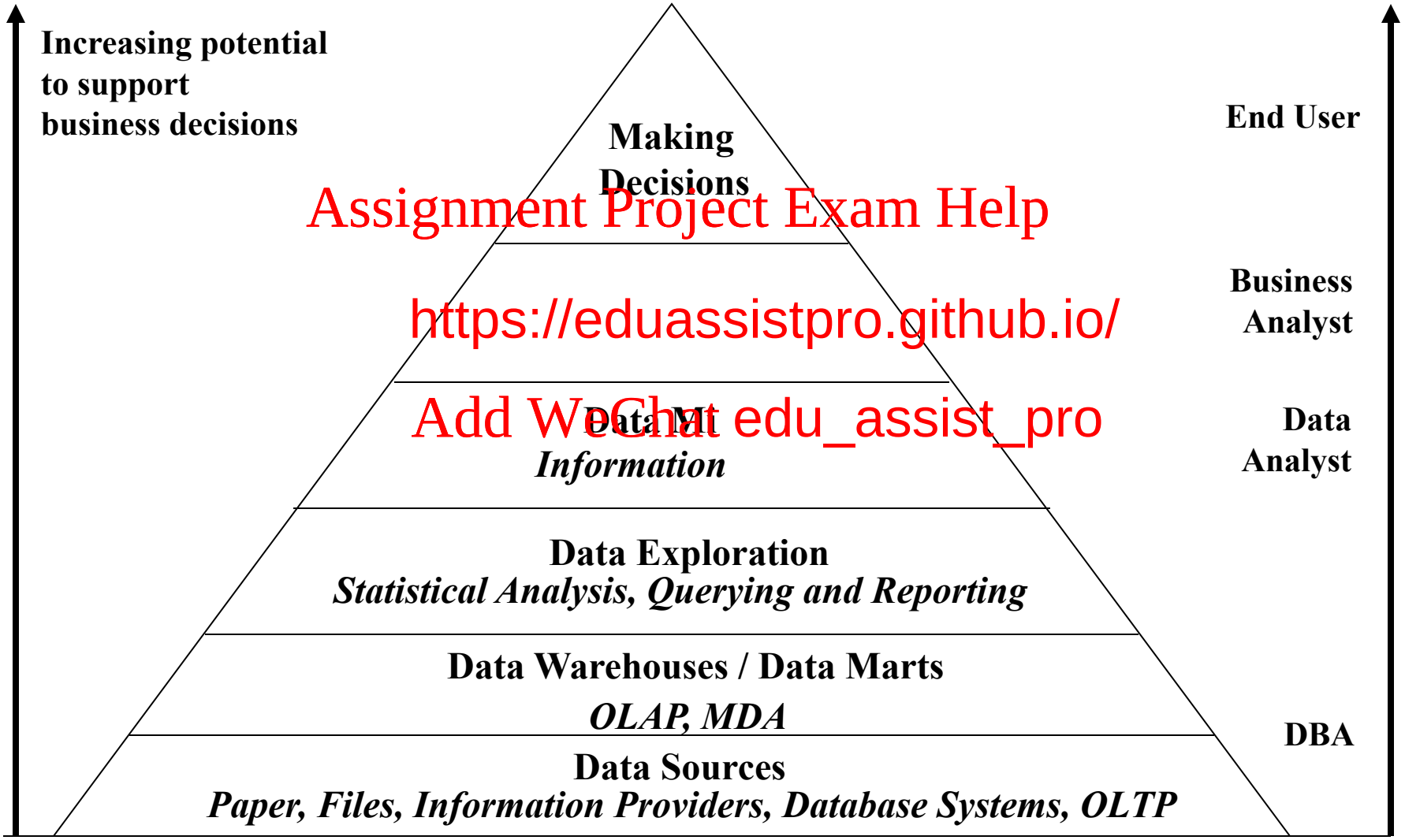
- Data mining—core of knowledge discovery process



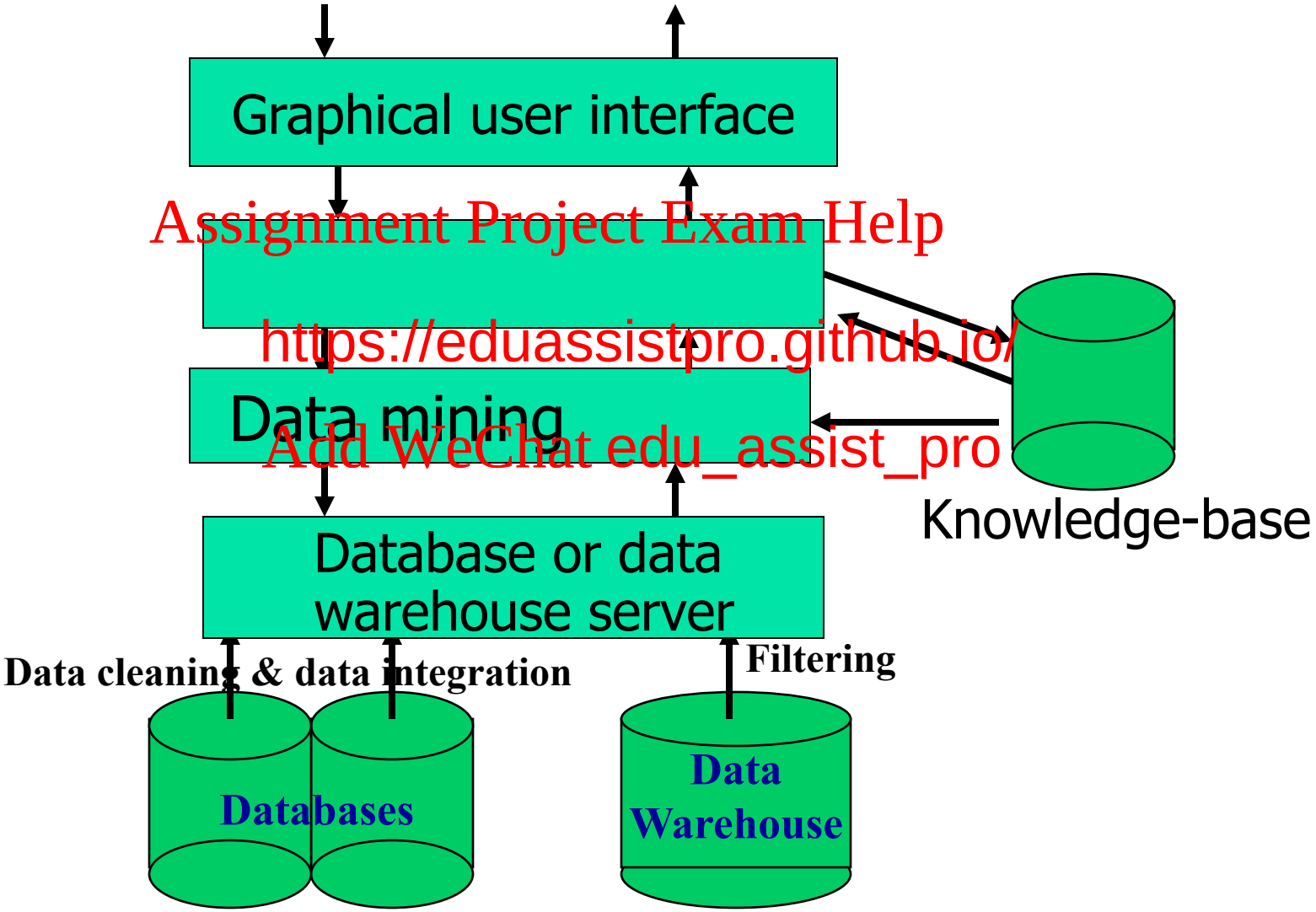
Steps of a KDD Process

- 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 an
  - Find useful featu uction, 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: Typical Data Mining System



Data Mining: On What Kinds of Data?

- Relational database
- Data warehouse
- Transactional database
- Advanced data and object-relational database
  - Object-relati
  - Spatial and temporal data
  - Time-series data
  - Stream data
  - Multimedia database
  - Heterogeneous and legacy database
  - Text databases & WWW

Data Mining Functionalities

- Concept description: Characterization and discrimination
  - Generalize, summarize, and contrast data characteristics, e.g., dry vs. wet regions
- Association (cor
  - Diaper → Beer
- Classification and Prediction
  - Construct models (functions) that describe and distinguish classes or concepts for future prediction
    - E.g., classify countries based on climate, or classify cars based on gas mileage
  - Presentation: decision-tree, classification rule, neural network
  - Predict some unknown or missing numerical values

Data Mining Functionalities (2)

- Cluster analysis
  - Class label is unknown: Group data to form new classes, e.g., cluster houses to find distribution patterns
  - Maximizing intra-class similarity & minimizing inter-class similarity
- Outlier analysis
  - Outlier: a data [illegible] with the general behavior of the data
  - Noise or exception? No! useful in [illegible]ion, rare events analysis
- Trend and evolution analysis
  - Trend and deviation: regression analysis
  - Sequential pattern mining, periodicity analysis
  - Similarity-based analysis
- Other pattern-directed or statistical analyses

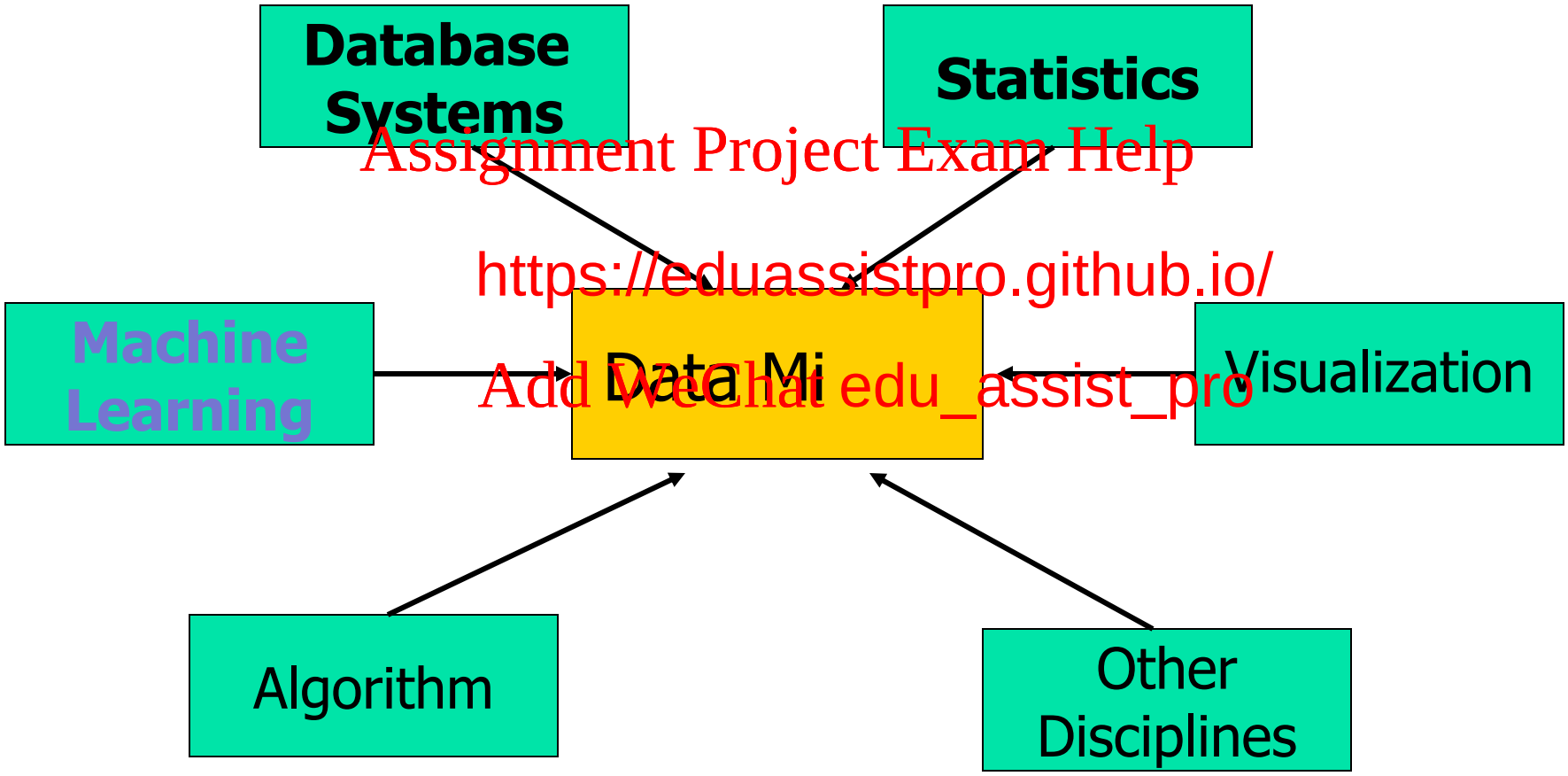
Are All the "Discovered" Patterns Interesting?

- Data mining may generate thousands of patterns: Not all of them are interesting
  - Suggested approach: Human-centered, query-based, focused mining
- **Interestingness measures**
  - A pattern is interesting if it is easily understood by humans, valid on new or test data with some degree of certainty, potentially useful, novel, or validates some hypothesis that a user seeks to confirm
- **Objective vs. subjective interestingness measures**
  - Objective: based on statistics and structures of patterns, e.g., support, confidence, etc.
  - Subjective: based on user's belief in the data, e.g., unexpectedness, novelty, actionability, etc.

Can We Find All and Only Interesting Patterns?

- Find all the interesting patterns: Completeness
  - Can a data mining system find all the interesting patterns?
  - Heuristic vs. exhaustive search
  - Association vs.
- Search for only int zation problem
  - Can a data mining system find o sting patterns?
  - Approaches
    - First generate all the patterns and then filter out the uninteresting ones.
    - Generate only the interesting patterns—mining query optimization

Data Mining: Confluence of Multiple Disciplines



Data Mining: Classification Schemes

- General functionality
  - Descriptive data mining
  - Predictive data mining
- Different vie ations
  - Kinds of data to be mined
  - Kinds of knowledge to be discovered
  - Kinds of techniques utilized
  - Kinds of applications adapted

Multi-Dimensional View of Data Mining

- **Data to be mined**
  - Relational, data warehouse, transactional, stream, object-oriented/relational, active, spatial, time-series, text, multi-media, heterogeneous, legacy, WWW
- **Knowledge to b**
  - Characterizatio , classification, clustering, trend/deviation, outli c.
  - Multiple/integrated functions an ultiple levels
- **Techniques utilized**
  - Database-oriented, data warehouse (OLAP), machine learning, statistics, visualization, etc.
- **Applications adapted**
  - Retail, telecommunication, banking, fraud analysis, bio-data mining, stock market analysis, Web mining, etc.

Major Issues in Data Mining

- Mining methodology
  - Mining different kinds of knowledge from diverse data types, e.g., bio, stream, Web
  - Performance: efficiency, effectiveness, and scalability
  - Pattern evaluation: the interestingness problem
  - Incorporation of b
  - Handling noise and
  - Parallel, distributed and incremental mi
  - Integration of the discovered knowledge e: knowledge fusion
- User interaction
  - Data mining query languages and ad-hoc mining
  - Expression and visualization of data mining results
  - Interactive mining of knowledge at multiple levels of abstraction
- Applications and social impacts
  - Domain-specific data mining & invisible data mining
  - 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 incl egration, data selection, transformation, da , 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.
- Data mining systems and architectures
- Major issues in data mining

A Brief History of Data Mining Society

- 1989 IJCAI Workshop on Knowledge Discovery in Databases (Piatetsky-Shapiro)
  - Knowledge Discovery in Databases (G. Piatetsky-Shapiro and W. Frawley, 1991)
- 1991-1994 Workshops on Knowledge Discovery in Databases
  - Advances in Knowled , G. Piatetsky-Shapiro, P. Smyth, and R. Uthurusamy,
- 1995-1998 International Conferences o iscovery in Databases and Data Mining (KDD'95-98)
  - Journal of Data Mining and Knowledge Discovery (1997)
- 1998 ACM SIGKDD, SIGKDD'1999-2001 conferences, and SIGKDD Explorations
- More conferences on data mining
  - PAKDD (1997), PKDD (1997), SIAM-Data Mining (2001), (IEEE) ICDM (2001), etc.

Where to Find References?

Web resources:
1. DBLP
2. Google
3. Citeseer
4. DL@lib

- Data mining and KDD
  - Conferences: ACM-SIGKDD, IEEE-ICDM, SIAM-DM, PKDD, PAKDD, etc.
  - Journal: Data Mining and Knowledge Discovery, KDD Explorations
- Database systems
  - Conferences: ACM-SIGMOD, ACM-PODS, VLDB, IEEE-ICDE, EDBT, ICDT, DASFAA
  - Journals: ACM-TO [illegible] J, etc.
- AI & Machine Lear[illegible]
  - Conferences: Machine learning (ML), AA[illegible] (Learning Theory), etc.
  - Journals: Machine Learning, Artificial Intelligence, etc.
- Statistics
  - Conferences: Joint Stat. Meeting, etc.
  - Journals: Annals of statistics, etc.
- Visualization
  - Conference proceedings: CHI, ACM-SIGGraph, etc.
  - Journals: IEEE Trans. visualization and computer graphics, etc.

Recommended Reference Books

- I. H. Witten and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufmann, 2001
- **C. C. Aggarwal, Data Mining: The Textbook, Springer, 2015□□**
- **J. Leskovec, A. Rajaraman, and J. Ullman, Mining of Massive Datasets (v2.1), Cambridge University Press, 2014.**
- Y. S. Abu-Mostafa, M. Mag Data. AMLBook, 2012.
- **J. Han and M. Kamber. ues. Morgan Kaufmann, 2001**
- **D. J. Hand, H. Mannila, and P. Smyth, Princip g, MIT Press, 2001**
- **T. Hastie, R. Tibshirani, and J. Friedman, The istical Learning: Data Mining, Inference, and Prediction, Springer-Verlag, 2001**
- **T. M. Mitchell, Machine Learning, McGraw Hill, 1997**
- **P-N. Tan, M. Steinbach, and V. Kumar, Introduction to Data Mining,. Addison-Wesley, 2005**
- S. M. Weiss and N. Indurkhya, Predictive Data Mining, Morgan Kaufmann, 1998

Jai's Project (COMP9318, 2016s2)

- Problem
  - http://kentandlime.com.au/, a startup company helping male customers to stay in fashion but out of the shops.
  - Status-quo:
    - Ask quest … a list of recomme… em to customers
    - If happy, customers pay … duct.
  - Recommendation is the ke…
- Challenges
  - Dirty data
  - Not an easy/typical recommendation system settings
  - Customer feedbacks
  - Real-time recommendations

http://www.news.com.au/lifestyle/fashion/fashion-trends/fashions-most-unlikely-trend-would-you-buy-clothes-chosen-for-you/news-story/8634b5f06f608b9f2fd7c27758f9c10a

Solutions - Highlight

- Use domain-knowledge and quick evaluations to guide the whole process

- Data preprocessing
  - Data source: DB (transactions)
  - Missing data hanges
  - Data normalization: AS XL
  - Data noise: k-means / binning
  - Data selection: remove sparse columns/rows

- Feature engineering
  - weight-to-height ratio

Solutions – Highlight /2

- Product class clustering and prediction
- Collaborative filtering with smoothing and weighting
- Content-based recommendation (solve the cold start problem
- Incorporate c
- Association rule mining:
  - LSShirts_1, Shorts_2 ➔ Socks_3
- Emsemble of the above

- Plus many engineering efforts

Results

- Test set:
  - Classification rate: 74%, on par with humans
- Deployed to production on 18-24 Nov 2016:
  - Customers rejecting on average 2.36 items out of a basket of 10 (0.3%)
  - Latency: 2.3
- Future work identified
  - e.g., seasonality

- Check Jai's presentation slides for more details.