Course Description:
This course introduces the basic concepts of data integration, data warehousing, and provenance. We will learn how to resolve structural heterogeneity through schema matching and mapping. The course introduces techniques for querying several heterogeneous datasources at once (data integration) and translating data between databases with different data representations (data exchange). Furthermore, we will cover the data-warehouse paradigm including the Extract-Transform-Load (ETL) process, the data cube model and its relational representations (such as snowflake and star schema), and efficient processing of analytical queries. This will be contrasted with Big Data analytics approaches that (besides other differences) significantly reduce the upfront cost of analytics. When feeding data through complex processing pipelines such as data exchange transformations or ETL workflows, it is easy to lose track of the origin of data. In the last part of the course we therefore cover techniques for representing and keeping track of the origin and creation process of data - aka its provenance.

The course is emphasizing practical skills through a series of homework assignments that help students develop a strong background in data integration systems and techniques. At the same time, it also addresses the underlying formalisms. For example, we will discuss the logic based languages used for schema mapping and the dimensional data model as well as their practical application (e.g., developing an ETL workflow with rapid miner and creating a mapping between two example schemata). The literature reviews will familiarize students with data integration and provenance research.

Course Material:
The following text book will be helpful for following the course and studying the presented material. Given the lack of text books on the topic, the part on data provenance will require literature study.


One of the following standard text books on databases in general may be helpful. However, this is not required reading material.


The slides will be made available on the course webpage.

Prerequisites:

- Courses: CS425
Course Details:
The following topics will be covered in the course:

- Introduction (3 hours)
  - Heterogeneity of data
  - Uncertainty and incompleteness
  - Autonomous and distributed data sources
  - Structured vs. unstructured data

- Preprocessing and Cleaning (4 hours)
  - Entity resolution
  - Data fusion
  - Cleaning

- Data Integration (10 hours)
  - Mediated schemata and query rewrite
  - Schema matching
  - Schema mappings

- Data Exchange (5 hours)
  - Data exchange transformations
  - Universal solutions

- Data Warehousing (10 hours)
  - Extract-transform-load (ETL)
  - Data cubes
  - Star- and snowflake schemas
  - Efficient analytics (OLAP) and relationship to transactional relational systems (OLTP)

- Big Data Analytics (3 hours)
  - Big Data analytics platforms and programming models
  - Differences between Big Data analytics and traditional warehousing approaches
  - Big Data integration

- Data Provenance (10 hours)
  - Why- and Where-provenance
  - Provenance polynomials
  - Provenance in data integration
  - Provenance for missing answers
Workload
The workload will consist of

1. A midterm and a final exam covering the topics of the course.

2. Several homework assignments. Over the course of the assignments the students will build a small data integration pipeline - starting from preprocessing, over schema matching and mapping, to transformation and query rewrite.

3. Review a research paper related to data integration, big data, or provenance.

4. Curate a real world dataset and present the result.

Course Objectives:
After attending the course students should:

• Understand the problems that arise with querying heterogeneous and autonomous data sources
• Understand the differences and similarities between the data integration/exchange, data warehouse, and Big Data analytics approaches
• Be able to build parts of a small data integration pipeline by “glueing” existing systems with new code
• Have learned formal languages for expressing schema mappings
• Understand the difference between virtual and materialized integration (data integration vs. data exchange)
• Understand the concept of data provenance and know how to compute provenance

Grading Policy:
The grading cutoffs are as follows:

• A: 80% or higher
• B: 50% or higher
• C: 35% or higher
• E: below 35%

The weighting of the individual components are:

• Data Curation Project: 20%
• Literature Review: 20%
• Midterm Exam: 30%
• Final Exam: 30%
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- Sexual harassment, sexual misconduct, and gender discrimination by any member of the Illinois Tech community is prohibited. This includes harassment among students, staff, or faculty. Sexual harassment by a faculty member or teaching assistant of a student over whom they have authority or by a supervisor of a member of the faculty or staff is particularly serious. Such conduct may easily create an intimidating, hostile, or offensive environment.

- Illinois Tech encourages anyone experiencing sexual harassment or sexual misconduct to speak with the Title IX Office for information on the resolution process and support options.

- You can file a complaint electronically at http://iit.edu/incidentreport, which may be completed anonymously. You may also file a complaint in-person by contacting the Title IX Coordinator, Virginia Foster at 312-567-5725 /mailto:foster@iit.edu or the Deputy Title IX Coordinator 312-567-5726 /mailto:eespeland@iit.edu.

- If you are not ready to file a formal complaint but wish to learn about your rights and options, you may contact Illinois Tech’s Confidential Advisor service at 773-907-1062. You can also contact a licensed practitioner in Illinois Tech’s Student Health and Wellness Center at 312-567-7550.

- For a comprehensive list of resources regarding counseling services, medical assistance, legal assistance and visa and immigration services, you can visit the Title IX Office’s website at https://web.iit.edu/hea/resources