Overview

Recent decades have witnessed the emergence of two important trends in software systems. First, an increasing number of software technologies have a significant social component (e.g. end-user programming, collaborative development tools). Second, software systems have increased significantly in complexity and size challenging traditional development and testing approaches. Empirical research methods play a key role in the evaluation of tools and technologies, and in testing the social and technical theories they embody.

This course provides an overview and hands-on experience with a core of qualitative and quantitative empirical research methods, including interviews, qualitative coding, survey design, and large-scale mining and analysis of data. There will be extensive reading with occasional student presentations about the reading in class, weekly homework assignments, and a semester-long research project for which students must prepare in-class kickoff and final presentations as well as a final report.

We will focus on software engineering related research questions in readings and assignments. Students will mine and integrate data from and across online software repositories (e.g., GitHub and Stack Overflow) and employ a spectrum of data analysis techniques, ranging from statistical modeling to social network analysis. For the final research project, we encourage students to come up with a research question of interest to themselves. The delivery will be a research paper, and one or more empirical methods presented in class have to be part of the paper.

Learning Goals

The learning goals describe what I want students to know or be able to do by the end of the semester. I evaluate whether learning goals have been achieved through assignments, written project reports, and in-class presentations. All learning goals are roughly written in a form "after taking this class, the student should be able to ...".

- Summarize and interpret a body of literature on a particular topic; identify gaps in the literature; write a literature review
- Formulate and motivate research questions
- Understand what research designs and research methods are available for empirical research
• Compare the suitability of different research designs and research methods in different scenarios; explain the relative strengths and weaknesses
• Design empirical studies for different purposes (e.g., evaluating a tool, understanding a phenomenon); choose appropriate methods and defend the choice
• Combine research methods in a mixed-methods design
• Collect and analyze qualitative and quantitative data
• Design interview protocols and user surveys
• Code qualitative data
• Mine data from online repositories
• Run statistical tests and interpret results
• Build, validate, and interpret regression models
• Draw conclusions from empirical data
• Present results verbally and in writing

Schedule

We cover the following topics (slides or notes posted when available):

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Evaluation

Evaluation will be based on the following approximate percentages:
● 40% assignments
● 50% research project
  ○ 10% initial project description (proposal)
  ○ 2% interim report
  ○ 8% final presentation
  ○ 30% final report
● 10% participation and in-class presentations

Syllabus

1. Contrasting methods
   a. Method:
   b. Reading
   c. Assignment:
      Read the assigned chapter and papers, and consider the differences in methods, the research questions they addressed, and the evidence they used to reach their conclusions. What does this tell you about the differences between qualitative and quantitative methods? In general, when is each type of method appropriate? What weaknesses does each method suffer from? Summarize your conclusions in 1-2 pages, and be prepared to informally present and discuss them in class.

2. Literature Review and Theory
   a. Method
   b. Reading
      ■ Theory-oriented papers:
Assignment
Critique the Xiao et al paper, specifically with respect to its use of theory. For example, you might consider
- Did the theory play a major role in framing the research questions?
- Was the methodology influenced by the theory?
- How did the theory impact the data that was collected and the way it was analyzed?
- How important was the theory to this research? Does it help explain the results? Does it help generate new questions?

3. Interviewing
a. Method
- (Ch 4&6). Interviewing as qualitative research: A guide for researchers in education and the social sciences: Teachers college press.

b. Example

c. Assignment
Think about a research idea that related to your own area and you need to collect information from stakeholders through interview. (see examples above)
1) decide what your purpose is and write a sentence describing it.
2) develop an interview protocol. The protocol can be short, focusing on exactly what you are interested in. You should anticipate short interviews, perhaps 15-20 minutes at most.
3) conduct two interviews.
4) be prepared to tell the class what you learned, how the interviews went, any problems or lessons you can share. In future classes, we will learn more structured ways of analyzing qualitative data such as interview transcripts.

4. Grounded Theory
a. Method

b. Example

c. Exercise
Transcribe the interviews you recorded last week. Write down a research question (or two) that you think you can answer with the interviews. Develop a suitable coding scheme for the collaborative writing interviews you performed, and apply the codes either to your detailed notes or (preferably your transcription of the interviews). Write an analytic memo (2-3 paragraph) based on these codes.

5. Survey
a. Method

b. Example

c. Assignment
Think about what you learned about from the interviews you conducted, and select an issue for further investigation that would be appropriate for a survey method. Design a short (8-10) item questionnaire that is well designed to address this issue, and enter the survey into an online tools such as surveymonkey. In a short writeup, provide a link to the questionnaire, discuss your selection of open versus closed ended questions, any issues that arose in the wording or presentation of questions, what population you would sample, and how you would invite participants.

6. Intro Quantitative Analysis
a. Method
- (Ch 10) Analysis and Interpretation. from C. Wohlin et al., Experimentation in Software Engineering, Springer-Verlag Berlin Heidelberg 2012
- (Ch 6) Statistical Methods and Measurement. from F. Shull et al. (eds.), Guide to Advanced Empirical Software Engineering. Springer 2008 (similar content as the Wohlin chapter but slightly different presentation; read one or the other)

b. Example


c. Assignment
In this assignment, you will practice basic quantitative data analysis methods. We will mine the 2017 Open Source Survey results from Zenodo: https://zenodo.org/record/806811 (https://zenodo.org/record/806811#.W7PD0y_Mz1L)

Formulate two research questions about participating in open source development, motivate them in 1-2 paragraphs with a few citations to relevant literature, and answer them using a quantitative analysis of data, e.g., based on ANOVA or multiple linear regression. Go beyond the basic frequency counts from R. Stuart Geiger's paper and focus your research questions on correlations, regressions, or descriptive breakouts between subgroups.

7. Experiment
   a. Method

   b. Example

   c. Assignment
      Design an experiment based on your previous analysis of the GitHub open source survey results. The experiment should allow you to either test (some of) the same hypotheses you explored statistically, or an interesting or suggestive finding emerging out of that analysis.

      Prepare a very short report describing your experiment design, including:
      ● your experimental hypothesis,
      ● a description of the experimental and control groups,
      ● your experimental procedure,
- acquiring or preparing any materials you need,
- the type of participants you require and how you would recruit them,
- how you would analyze the data,
- analysis of the threats to validity

8. Quasi-experimental Design & Linear Regression
   a. Method
      - (Ch 1&2) General Aspects of Fitting Regression Models. F.E. Harrell, Jr., Regression Modeling Strategies, Springer Series in Statistics, Chapters 1&2 - Regression general aspects: [Chapter 1: skim] [Chapter 2: read 2.1--2.3, 2.7]
   b. Example
   c. Assignment
      We are going to use the Aminer data set (https://www.aminer.org/aminernetwork), which contains information on papers, paper citations, authors, and author collaborations for more than 1.7 million computer science authors, to conduct quantitative analysis.

     Please Formulate one research question about academic publishing / scientific impact, motivate it in 1-2 paragraphs with 3+ citations to relevant literature, and answer it using a quantitative analysis.

9. Time Series Analysis
   a. Method
   b. Example
   c. Assignment
      Use the same AMiner data set from the previous assignment to answer a research question of your choosing with an interrupted time-series design. For example, you can
use the affiliations data to answer: Do researchers publish increasingly more papers after they join / leave UofT, compared to before? (in this case the "intervention" is joining / leaving UofT) Be creative!

10. Mixed-Methods
   a. Method
   b. Example
   c. Assignment
      How would you turn your quantitative studies from last weeks (either regression or time series analysis) into a mixed-methods design? Pick one of the studies. Write 1-2 paragraphs describing the mixed-methods design. Which method(s) would you add? How would you combine them? Which specific threats to validity of the quantitative study would this mixed-methods approach help reduce?

11. Text Mining
   a. Method
   b. Example
   c. Assignment
Add a research question to either your previous regression or time series studies and use LDA to answer it (or use LDA as an additional method in a mixed-methods design). Ideally use the LDA to calculate some feature(s) and use this feature in a multiple regression model.

12. Social Network Analysis
   a. Method
   b. Example
   c. Assignment
      Explore a research question of your choice on the AMiner collaboration data set, such that your methods include (1) social network analysis, and (2) multiple regression.