Experiment Design for Computer Sciences (0AL0400)

Topic 00 - Course Introduction

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Part I – What is this course about?

What is this course about?

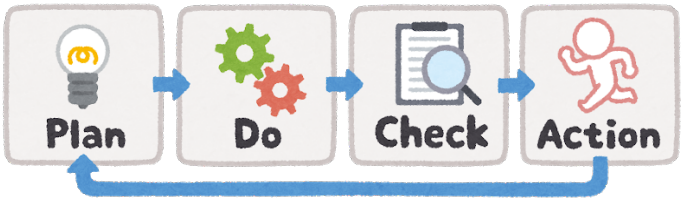
From the syllabus

The collection and analysis of data through experiments is one of the cornerstones of the scientific method. In this course, we study the general philosophy and methods behind experimentalism: Why do we perform experiments, what is a good/rigorous experiment, how to plan and design a rigorous experiment, and how to perform statistical analysis on experimental data.

What does this mean?

What is this course about?

The key idea of this course is to learn how to do an experiment in a systematic manner.



i.e., "how to apply the PDCA cycle for science?"

Why is this course necessary?

Frequent errors when designing an experiment

There are some errors that are often found in CS experiments:

- The experiment does control for noise;
  Problem: Is the result just a coincidence?
- The experiment does unfair comparisons between methods;
  Problem: Is the result valid in the general case?
- The experiment is not clear / not reproducible;
  Problem: Can this experiment help other people?
- etc...

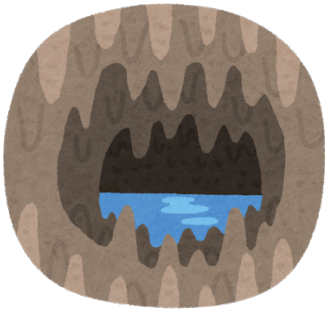
Many of these errors happen because of experiments done carelessly. So let's learn to think more carefully about them!

Why is this course necessary?

The "Invisible Curriculum" – things that are not taught in classes

The Invisible Curriculum are things that are necessary for your work as an academic, but that you usually can't learn in a lecture, and must discover by trial and error. For example:

- How do I prepare an experiment?
- When do I publish a result?
- How do I review a paper?
- How do I teach a lecture?
- What are grants?
- ...



The goal of this course is to shed light in one of these points:
What is an experiment, and how do I prepare it?

Course Topics

The main things that you will learn in this course are:

- What is an experiment:
  - What is the role of an experiment in Science?
  - How do I design an experiment to answer a scientific question?
  - What are the characteristics of a good experiment?
  - How do I analyse the results of an experiment?

- Statistical tools for analyzing experimental data:
  - Basic statistics for data analysis and visualization;
  - Statistical Inference ("Statistically Significant Results");
  - Statistical testing for single, paired, and multiple sample testing;
  - How to calculate the sample size and power of an experiment;

Course Topics

Limitations: This is only an introductory course!

This course is an introduction to design of experiment. My main objective is to teach you why designing experiments is important, and what problems can happen when you don't do this. Not to teach all the statistical tests.

Each experiment, in each research, will require a different way of doing statistical analysis. Also, some advanced topics (bayesian statistical analysis) will not be covered here. I hope that after this course you will have a solid understanding of the concepts to read and learn the advanced tests required of your own research.

Part II – Practical Details

Practical Details about the course

- Class Format;
- Communication Channels;
- Course Materials;
- Course Schedule;
- Grading;
- Other topics;

Note: The latest and most correct information about course policy is always on manaba.

Class Format – In person (Online Support)

- The lectures will be in person.
  - The class materials do not fill the entire 150 minute period (about 1 hour material).
  - I like to ask plenty of questions, and hold discussions during class.
  - Also, breaks when necessary.
- Final exam will be in person too.
- If you cannot come to class, videos from last year will be available.
  - In that case, please ask questions on manaba!

Communication Channels

Communication between us is very important. Do not leave questions unanswered!

Communication channels by priority:

1. Ask questions during the class. The material does not cover the full class time, so you can stop and ask if anything is not clear.
2. Use the manaba forums to ask questions outside of class hours. By opening a forum thread, other students with similar questions can also see the answer.
3. Feel free to e-mail me if you have questions that can not be shared with other students.

Also, every lecture I post an Attendance Survey on manaba. The survey is not graded, but you must take the survey to count for attendance!

Course Materials

- The lecture notes are published in the "manaba" system.
- Access code for 2023: 9352484. Use this code if you can't access manaba yet.
- The course materials are also available on github: `https://caranha.github.io/ExperimentDesignCS/`.
- This year, the course is fully in person. I strongly recommend that you come to class. However, the videos from 2022 will be listed on Manaba if you need to miss a lecture.
  - Please note that there may be new material not covered in the videos.

Course Materials

Acknowledgements

The lecture notes were produced based on the "Design and Analysis of Experiments" material produced by Felipe Campelo. You can reach the original lecture notes on: `https://github.com/fcampelo/Design-and-Analysis-of-Experiments`

All good ideas are thanks to Felipe (and other contributors) all errors are my own :-)
(Please submit errors as github issues!)

Course Materials

Books and Links

- The list of books, papers, and webpages used to assemble this course is listed on manaba and on github.
- Please do extra reading. It is not possible to cover all topics related to experiment design in just one semester.

Course Schedule

- 4/14 Topic 01 – Course Introduction, What is Experimentation
- 4/21 Topic 02 – Point and Interval Indicators
- 4/28 Topic 03 – Inference Testing I
- 5/05 (Golden Week, no Class)
- 5/12 Review – Class Review and Discussion of Report I
- 5/19 Topic 04 – Inference Testing II
- 5/26 Topic 05 – Inference Testing III
- 6/02 Topic 06 – Sample Size and Experiment Power
- 6/09 Topic 07 – Block and Factorial Designs I
- 6/16 Topic 08 – Block and Factorial Designs II
- 6/23 Review – Class Review and Consultation about Report II
- 6/30 Final Exam

Grading

Two reports (R1, R2), and a final examination (E). Each graded from 0 to 100. The final Grade (FG) is:

$$FG = 0.2 * R1 + 0.4 * R2 + 0.4 * E$$

The letter grade for this course follows the Tsukuba standard
($< 60 : D; < 70 : C, < 80 : B, < 90 : A$)

Grading

Final Examination

- Covers the topics of the entire course.
- Must be answered in English.
- You may prepare one A4 page of handwritten notes (both sides), and use it on the test.
  - The notes have no fixed format, and can be in any language.
  - The notes must include your name and student ID, and must be turned in with the exam. The notes will not be graded.
- You can bring a dictionary to the exam.
- No other consultation is allowed in the exam.

Grading

Reports

Two "mini-papers". The student must plan, perform, and analyze an experiment of their own choice:

- Choose a scientific question to answer
- Design an Experiment to gather data to answer that question
- Execute the experiment, following the design
- Analyze the data, following the design
- Make a conclusion, based on the analysis of the data

The different between report 1 and report 2 are the expectations.
Please see details in manaba.

Other Topics:

Self Introduction

- Name: Claus Aranha;
- Country: Brazil;
- Research Topics:
  - Evolutionary Algorithms;
  - Artificial Life;
- Hobbies:
  - Game Programming;
  - Geocaching;
- webpage:
  `http://conclave.cs.tsukuba.ac.jp`

Ask me anything you want!

Part III - Report I

Report I

General Information

Write a "mini paper" about an experiment that you choose, prepare, execute and analyze. Specifically, you must:

- Choose a question to investigate using a scientific experiment.
- Design the experiment (choose variables, data collection and analysis protocol)
- Execute the experiment following the data collection protocol.
- Analyze the data obtained following the data analysis protocol.
- Take note of any surprising or unsurprising findings, and prepare a conclusion for the experiment.

The report must summarize the above points (the question, experiment designs, data collection, data analysis, and conclusion).

Report I

Expectations

In the first report, you should select a simple experiment with a single dependent variable and a single independent variable, and calculate simple statistical intervals of values observed for the dependent variable. These topics are covered in lectures 1 and 2.

The report will be graded by:

- Whether it describes a coherent scientific experiment to answer the chosen question;
- The quality of the data analysis;
- The quality of the result presentation and discussion;

Note that you are NOT expected to use the null-hypothesis model in this report (lectures 4-6). Doing the test wrongly may deduct points.

Report I

How to choose an experiment topic

- If possible, choose something from your own research;
- Experiments from your day to day life are also good;
  - Comparing cooking techniques is always fun;
  - When collecting data, be careful of measuring errors;
- When in doubt, comparing algorithms is an easy choice;
  - Make sure to choose an appropriate metric to report!
- Make sure you choose an experiment that you can perform!
- This article might be insightful: `https://williamghunter.net/articles/101-ways-to-design-an-experiment`

Report 1

Rules and Deadlines

- Report Deadline: 05/01, 23:00 – submit on manaba
- The report must be in English.
- Submit the report as a PDF file, don't forget your name/ID.
- Submit also a ZIP file with all the data/scripts necessary to reproduce your analysis.
- Aspiring scientists should be specially wary of plagiarism. Please see manaba for details.

About these Slides

These slides were made by Claus Aranha, 2022. You are welcome to copy, re-use and modify this material.

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Individual images in some slides might have been made by other authors. Please see the following references for those cases.

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