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?

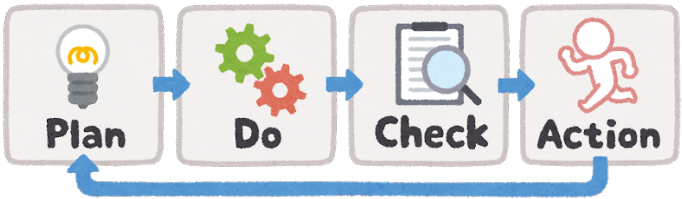
From the syllabus

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...

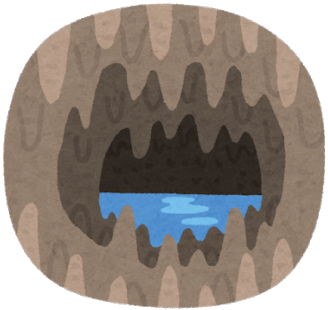
Many of these errors happen because of experiments done carelessly. So let's learn to think more carefully about them!

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 – Online, On demand

- We have students in several time zones, so I will teach you using pre-recorded videos and lecture materials.
  - Please watch the videos in full, at a time and speed of your convenience. Videos are published on Youtube and Teams.
- On Fridays, 15:15-18:00 JST, I will hold "office hours" to answer questions about the class and anything else.
  - I will not count attendance on office hours. Come if you have questions.
  - I will be online on TEAMS, and you can also come to my office if you want (SB904).
  - Please send a message if you come to my office.
  - If you cannot come to the office hours, please see the next slide.
- Exception: The final exam is Online Syncronous. If this is too difficult for your timezone, please talk to me.

Communication Channels

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

Communication channels by priority:

1. Office Hours, Friday, 15:15-18:00 on Teams (or my office)
2. Manaba Forum, Other students can benefit from your questions.
3. E-mail, if it really needs to be private.

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.
- If you are a student of the University of Tsukuba, but not registered for the course, you can access manaba with the following key: 7745902
- If you are not a student of UT, you can access the course material in the following github repository (caveat emptor!)
  `https://caranha.github.io/ExperimentDesignCS/`.
- Videos are published on Youtube and Teams, and you can watch them later (I will de-list videos from the previous year).

Course Materials

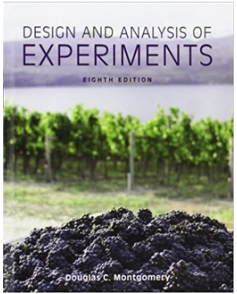
Acknowledgements

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



Many topics in this course are explored in much more depth on "Design and Analysis of Experiments", by Douglas C. Montgomery.

I add more links, papers, and other resources on manaba / github.

Course Schedule

- 4/15 Topic 01 – Course Introduction, What is Experimentation
- 4/22 Topic 02 – Point and Interval Indicators
- 4/29 Topic 03 – Inference Testing I
- 5/06 (Golden Week, no Class)
- 5/13 Review 01 – Class Review and Discussion of Report I
- 5/20 Topic 04 – Inference Testing II
- 5/27 Topic 05 – Factorial Designs
- 6/03 Topic 06 – Inference Testing III
- 6/10 Topic 07 – Sample Size and Experiment Power
- 6/17 Topic 08 – Case Study: Statistical Comparisons of Classifiers over Multiple Data Sets
- 6/24 Review 02 – Class Review and Consultation about Report II
- 7/01 Final Exam (Online)

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:

1 – Computer Science English Program (CSE)

The CSE supports a master degree fully in English. If you plan to take most of your classes in Enslish, do not forget to enroll in the CSE:

Send an e-mail to s-g30@cs.tsukuba.ac.jp with this info:

- Your name (ASCII and Kanji)
- Student ID

For more information, see the orientation material at the "New Student Orientation" course on manaba.

Other Topics:

2 – 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: 05/02, 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.
- Plagiarism will be severely punished.

About these Slides

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

These slides are a modification of "Design and Analysis of Experiments (2018)" by Felipe Campelo, used with permission.

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

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