Experiment Design for Computer Sciences

Introduction and Important Points

Claus Aranha

http://conclave.cs.tsukuba.ac.jp/

Computer Science Department

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Lecturer Introduction

Who am I?

- Name: Claus Aranha;
- Country: Brazil;
- Research: Artificial Intelligence, Evolutionary Algorithms, Genetic Programming;
- Language: R, Lua, Python, C++, Java;
- Hobbies: Game Programming, Geocaching;

Motivation

Why is this course necessary?

Many of you love maths, programming and technology. You want to create new gadgets and services. And now you are in your master degree.

Although there is a lot of overlap between the **hacker** and the **scientist**, there are some research related skills that many computer science students lack.[a]

The goal of this course is to introduce you to skills critical to perform scientific research (and which are nonetheless useful for engineering as well)

[a] Julian Togelius has some nice insight about this different in see this post.

Motivation

A common example (1)[b]

You are a M1 student is studying neural networks to identify cat pictures. First, you use a common DNN structure from a web tutorial, and gets 90% recall rate. Your advisor tells you need to create a **novel** algorithm and a better result.

You decide to try to use a polinomial as the activation function of a DNN (they are easy to derive...). After 5 months and a lot of trial-and-error, you get a 95% recall rate with a 5-degree polinomial function! Yay!

Your advisor is happy, and you get a lot of positive feedback from the laboratory seminar. So now you try to publish you findings as a paper.

Everything perfect...

[b] CC0 image from pixabay

Motivation

A common example (2)

Reviewer 1 (Major Revisions)

What is the sensitivity of your method to the parameters of the polinomial?

Reviewer 2 (Reject)

You need to perform an analysis of the significance of your experimentl result.

Reviewer 3 (Reject)

Why did you use a 5 degree polinomial? Why not 4? Why not 7?

Reviewer 4 (Weak Accept)

You only use Tabby cat pics. What about siamese cats?

... And, when you try to use siamese cat pictures, you get a 91% recall!

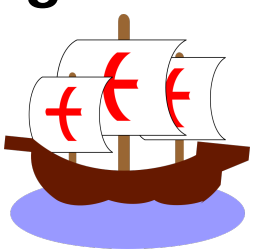
Motivation

What happened?

The truth is that there is a big gap between hacking and science. The issues raised by the reviewers could have been preemptively solved by careful planning of the experiment:

- What are the parts that can change, and to what limits?
- How much can these changes affect the final result?
- Which of these changes can be controlled, and which cannot?
- If we control the changes, which values do we set?
- How many times we test these different combinations?

Hacking relies on talent, determination and intuition. While science also needs these things, it also needs a lot of **Careful Planning**.[c]



[c] CC0 image by jamonero from `https://www.openclipart.org`

Motivation

In this course you will learn:

- The role of experimentation in the scientific method;
- The principles of experimentalism;
- How to design an experiment, so you know what kind of result to expect before you start gathering data;
- The statistical tools for experiment data analysis and their mathematical background (with lots of examples)
- Some hints, tips and tricks on how to do SCIENCE!

Grading System

Or the part that everyone really wants to know (1)

This class is graded on a weighted average of four reports:

- R1: Mini-experiment (weight 1)
- R2: Report on own research (weight 2)
- R3: Case Study (weight 3)
- R4: Experiment Report and Presentation (weight 4)

$$\text{Final Grade} = \frac{1R_1+2R_2+3R_3+4R_4}{10}$$

Grading System

Or the part that everyone really wants to know (2)

Mini-experiment – Weight 1

Create a short, simple experiment based on his day to day experience, and submit a 1-page report on it.

Report on your own research – Weight 2

Write a short description of your research theme, identifying what would be experimental parameters, sources of uncertainty, and describe a well designed experiment in your research following the themes of this lecture.

These two reports are due before week 3!

Grading System

Or the part that everyone really wants to know (3)

Case study – Weight 3

Based on an experiment description and data provided by the instructor, write a report analysing the data properly using the methods discussed in class.

Experiment, report and presentation – Weight 4

Groups of two students must choose an experiment idea, design the experiment, perform the experiment, analyse the results and present their findings at the end of the semester.

These two reports are due before by the last class!

Calendar

- 04/13 Week 1: What is Science? (Chapter 1)
- 04/20 No Class – ICPC World Finals
- 04/27 Week 2: The role of Experimentation (Chapter 2)
- 05/04 No Class – Golden Week
- 05/11 Week 3: Basic Statistics (Chapter 3 and 4)
- 05/18 Week 4: Hypothesis Testing (Chapter 5)
- 05/25 Week 5: Comparisons (Chapters 6 and 7)
- 06/01 Week 6: Non Standard Situations (Chapters 8 and 9)
- 06/08 Week 7: ANOVA and multiple comparisons (Chapter 10)
- 06/15 Week 9: Choosing Experiments (Chapter 11 and 12)
- 06/22 Week 10: Final Review/Substitute Class
- 06/29 Final Presentation

Materials

Reference Materials for this Course (1)

- Design and Analysis of Experiments Repository
- Manaba Online Classroom
- Books and Online Reads

Our main material for this course are the “Design and Analysis of Experiments” lecture notes, prepared and gracefully shared by Felipe Campelo from UFMG.

We will use a fork of this material that contains some extra information for Tsukuba, you can access it in this repository:

github.com/caranha/Design-and-Analysis-of-Experiments

Materials

Reference Materials for this Course (2)

- Design and Analysis of Experiments Repository
- Manaba Online Classroom
- Books and Online Reads

Copies of all PDFs, information about class structure, and Report submission will happen on the MANABA System. Please check freuently.

MANABA Page:
`https://manaba.tsukuba.ac.jp/ct/course_946366`

Registration Code: 2567624

Materials

Reference Materials for this Course (3)

- Design and Analysis of Experiments Repository
- Manaba Online Classroom
- Books and Online Reads

Each chapter in the Github has a list of required and suggested readings. These are usually quite short link, so be sure to read them!

In MANABA, there are lists for extra interesting links and videos not related to any one chapter in particular.

Expectations from the Students

Self Study Requirements 1 – Books

This course only convers a small (but significant [d]) part of D&AoE techniques. In particular, each research might use slightly different methods depending on the type of experiments and data used.

Therefore, it is essential that you **complement the classes with personal studies** from other sources. A good start is the course textbook:

- D.C. Montgomery, Design and Analysis of Experiments, Wiley, 2005

If you come across other material on the subject, feel free to recommend it to the rest of the class.

[d] pun intended

Expectations from the Students

Self Study Requirements 2 – R Language

This course relies on many examples and case studies using the R language. It is **essential** that you familiarize yourself with this tool.

I recommend that you use the **RStudio**[e] IDE. Also, Coursera has regular **tutorials on R programming**[f] that can be easily completed in one or two weeks by anyone with familiarity in other programming languages.

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[e] https://www.rstudio.com

[f] https://www.coursera.org/learn/r-programming/

Expectations from the Students

Self Study Requirements 3 – English Language

Note: writing clarity and correctness will count towards your grade. I don't expect any Shakespeare or Asimov, but **reports consisting solely of code and figures** are not acceptable.

If you are not confident of your English abilities, professor Neil Millar[g] teaches the following courses for graduate level technical English:

- Introductory Technical Writing: 02CA101
- Advanced Technical Writing: 02CA103
- Science Communication I: 02CA105
- Science Communication II: 02CA107

[g] mailto:millar@cs.tsukuba.ac.jp

Expectation from the Students

Student Behavior 1 – Attendance (or lack thereof)

I know that many of you will be busy with lab activities and your own research. I like to treat my students as responsible adults, so:

- **I do not take attendance for this course.** If you have to miss a class because of a lab meeting [h], you have my blessings.
- I am happy to answer questions about the course by e-mail, but discussions after class are much better for explaining complex topics.
- Also, I am happy to discuss your personal research work, specially how to apply the contents of this course to your research.
- I **do expect** you to submit all assignments in time and participate in the final presentation.

Make sure that you can afford to miss class! If you don't come to class and don't study the required readings, and don't ask me questions, there is not much I can do to help you.

[h] Or because Paradox released new DLC for EU4

Expectation from the Students

Student Behavior 2 – Plagiarism

Copying the work of one person is Plagiarism, Copying the work of many people is Research

– Graduate Proverb.

I take a **very serious** view of plagiarism. Copying text or code from others without proper attribution will affect your grades and, in worse cases, may cause problems for your graduation.

On the other hand, (properly attributed) use of previous works, data and source codes is an important part of academic work, and encouraged. Don’t reinvent the wheel.

When in doubt, don’t hesitate to ask!

The End!

Now let's get started

Questions?

Then Let's have fun! Time for the door of death...