Research Methods

What the class is about:

- how to do research
- projects where you demonstrate to me that you've learned the methods

What the class is not about:

- philosophy of science
- debates on what good computer science research is

Is there consensus about proper research methods in computer science?

NO

What methods will we learn in this class?

MY METHODS

How will you be evaluated in this course?

Science

1. Establish relationships or other facts
2. Organize these relationships into a body of knowledge

Relationship between X and Y

X: design of cache Y: its performance

X: Java experience Y: errors in C code

X: test suite generation method

Y: ability of suites generated via that method to find errors

X: size of button Y: errors and speed of clicking

Two Ways to Establish Relationships

(1) Induction

① observe. ② draw conclusions that emerge out of your data.

possible to induce something false from true statements.

(2) Deduction

① start with a general theory.

② deduce what the theory says about a specific situation → hypothesis

③ design a study to build evidence for your hypothesis.

→ correlational observation

→ experimentation

Induction Techniques

- ethnography
- contextual inquiry
- cognitive task analysis

and techniques that could be used for induction:

1. interviews
2. surveys
3. measuring quantitative data

Deduction

① start with a general theory.

② deduce what the theory says about a specific situation → hypothesis

③ design a study to build evidence for your hypothesis.

→ correlational observation
directionality problem
third variable problem

→ experimentation

Correlational Observation

- measure X and Y

Randomly choose a bunch of people with a laptop.

Measure X: laptop size

and Y: errors they make

Imaginary result:

People with smaller laptops make more errors.

Or is it: Error-prone people like to buy smaller laptops:
(directionality problem)

Or is it: Rich people make more mistakes and also choose smaller laptops
(third variable problem)

Experimentation

Strongest method for testing a causal hypothesis.

→ change in A causes a change in B

A: independent variable
B: dependent variable
} measurable

An experiment needs ≥ 2 levels (treatment level) of the independent variable.

→ solves directionality problem

An experiment should have most other relevant variables "under control"

→ solves 3rd variable problem

Control variables

→ don't vary throughout the experiment

Make everything a control variable?

→ then you cannot generalize your results.

Random variables

→ random selection: choose randomly from a population to get a representative sample

→ random assignment: randomly assign participants to a treatment level.

Constrained variables

- deliberately assign values of these variables to treatment levels

confounding variables

→ anything other than the indep. var. that could have caused a change to a dep. var.

Threats to Validity of Your Experiment

Internal validity: does experiment show changes in indep. var. cause changes in dep. var.?

Threats to IV:

- learning effects
- history effects
  (what happened b/w applications of treatment levels?)
- self-selection
- sensitivation to topic
- differential mortality
  (dropping out)

More Threats to IV:

- ignoring error in measurement

External validity: generalizability of results

↑ #control variables

→ ↑ internal validity

↓ external validity

Threats to EV

- poor match between what you measure and what you actually care about

Product evaluation

→ a common type of research in systems, PL, SE, HCI

A Theory lends you to believe that building X is a good idea.

So you build X.

Then, you hypothesize some claims about X are true.

indep. var. : absence / presence of X

dep. var: metric you care about

Experiment is what matters, not the product!

Principles of Scientific Investigation

① Objectivity

- any two researchers studying the same relationships should reach the same results

note: explicit bias is better than false objectivity.

② Replication

- research should be repeatable with similar results

③ Reliability

- measurements should be repeatable with same results

④ Critical Perspective

- scientists look for holes in their own arguments

Example

Theory of Reading [Adler, O'Hara and Selken, Marshall and Bly]

- multiple documents read at one time
- people read, skim, and glance
- people flip through a book in addition to reading start-to-end

Hypothesis: ?

Experiment:

Dependent Var:

Indep. Var:

Control Variables:

Random Variables:

Constrained Variables:

Confounding Variables: