

Research

What is research?

and

What is software engineering research?

Solving a problem

Write a program so that:

if $X > 0$ then $Y = \sqrt{X}$

As a lower division course:

Write a program using Newton's method to compute square roots so that:

if $X=1, Y=1; X=4, Y=2; X=25, Y=5$

Basic algorithm is specified. Must translate algorithm into correct executable code.

As an upper division course:

Write a program to compute square roots, and show that it generates an answer of at least 5 significant digits.

Algorithm unspecified. Must develop algorithm into correct executable code.

MS Research

As an MS project:

Investigate algorithms for computing square roots and determine which ones converge more efficiently for which sets of numbers

Goal is less on the actual program, but an understanding of what has been learned about square root processes and their implementations.

→ Can you do an independent investigation of a relevant topic.

PhD Research

As an PhD project:

Investigate algorithms for computing roots and determine properties for these programs which are most efficient for computing the n th root of a real number.

Goal now is to understand the nature for the computation process and develop some new ideas about this class of program.

→ Can you do an independent investigation to develop some new ideas on an old theme.

Too many students get hung up on the word "new". Very few PhD dissertations are truly ground-breaking in their results - in spite of the opinion of those writing those dissertations.

One sign of maturity of a new assistant professor is when they realize that their dissertation is not the "hammer" and all problems are "nails."

Software Engineering Research

Somewhat different from other branches of computer science

- **Most areas look at application domains:**
 - How can you develop better robot motion? (computer vision)
 - How can NASA store and retrieve 3 terabytes/day? (database)
 - How can the Internet prevent email spam? (networking, operating systems)
 - How can you prevent break-ins on your home wireless network? (security)
- **Software engineering looks at the software development process, itself, across any of these application domains:**
 - To paraphrase the old Crown Books ads: "Why does software cost so much?"

One example

High performance computing (HPC):

- An operating system and computer design problem: How can we make computers run even faster?
- General solution: Electrons only go so fast. Add parallelism to make machines even faster.
- Software techniques developed to program these machines.

Issue: How hard is it to program these machines?

- Can we use a slightly "slower" but easier to program architecture and get a better overall performance?
- Will the probability of programming error be less using one technique over another?
- What is the economic value (ROI - return on investment) of using one architecture over another?

None of these have been addressed previously. HPC community hasn't even thought of these as issues.

Summary

Gross oversimplification of the problem

- Theory research: Questions easy, solutions hard

Does $P = NP$?

Fermat's last theorem

- Software engineering research: Questions hard, solutions relatively easy

Where is it important to compute the ROI of a process and how do we compute it?