CSE 331
Software Design & Implementation
Katherine Murphy

Credits: Profs. Kevin Zatloukal and James Wilcox
About Your Instructor

Katherine Murphy
About Your Instructor

• Undergrad @ UW CSE

• Current MS student

• Previous CSE 331 TA
  – 12 quarters of experience
  – Built and maintained course infrastructure
Software Development Process

Given: a problem description (in English)

- **Idea Generation**
- **Type Checking**
- **Reasoning**
- **Testing**

**Debugging**

*Reasoning* = “thinking through” what the code does on all inputs

*Debugging* = searching back from a failure to find the bug
Software Development Process

Given: a problem description (in English)

Beta users are understanding about failures, but regular users are completely unforgiving!
(Regular users do not give credit for effort.)
Software Development Process

Given: a problem description (in English)

In principle, purple parts can all be automated.

Profs of CSE 331 Past Prediction: AI will be able to write all programs that can be built using only these parts within 5 years.
Software Development Process

Given: a problem description (in English)

- Idea Generation
- Type Checking
- Reasoning
- Testing
- Debugging

Profs of CSE 331 Past Prediction: AI will be able to write all programs that can be built using only these parts within 5 years.

Corollary: expect only to be paid for reasoning and debugging
"Engineers are paid to think and understand."
— Class slogan #1
Reasoning is Required

• **In principle:** you have a *professional responsibility* to think through what your code does on all allowed inputs
  – unethical to send code to users and just hope it works

• **In practice:** skipping reasoning up front means debugging... and then reasoning afterward
  – second approach is more work
    debugging is hard!
  – problems you get paid to solve are never solved “by accident”
    too many ideas for you to bump into the solution by accident
“Reasoning is not optional: either reason up front or debug and then reason.”

— Class slogan #2
Reasoning is Expected

• **In industry:** you will be expected to think through your code
  – standard practice is to do this *twice* (“code review”)
    you think through your code then ask someone else to also

• **Professionals spend most of their coding time reasoning**
  – reasoning is the core skill of programming

• **Interviews have always been tests of reasoning**
  – take the computer away so you only have reasoning
  – typical coding problem has lots of cases that are easy to miss
    if you don’t think through carefully
  – *(not about knowing “the answer” to the question)*
    interviewers will throw out interviews that went too well!
Reasoning is Unlikely to be Automated

- Reasoning & Debugging are provably impossible for a computer to solve in all cases

- Also seems to be hard for AI in practice
  - AI is bad at rare cases...
Cruise Autonomous Car Gets Itself Stuck In Wet Cement
Reasoning is Unlikely to be Automated

• Reasoning & Debugging are provably impossible for a computer to solve in all cases

• Also seems to be hard for AI in practice
  – AI is bad at rare cases (you get paid for thinking those through)
  – AI is bad at holistic understanding (necessary for debugging)
Reasoning is Unlikely to be Automated

• Reasoning & Debugging are provably impossible for a computer to solve in all cases

• Also seems to be hard for AI in practice
  – AI is bad at rare cases (you get paid for thinking those through)
  – AI is bad at holistic understanding (necessary for debugging)
  – AI fails to learn general properties despite seeing 1b+ examples
    e.g., A parent of B means that B is a child of A
  – such properties are fundamental to (formal) reasoning
    e.g., we know that a < b means b > a
    would be hard to do algebra without that knowledge
“These models have read every piece of code on Github, every StackOverflow question answer, every programming book, every tweet about coding, transcripts of every YouTube walkthrough and they still can’t code as well as I can in every situation.”

— Nat Friedman (former GitHub CEO)
Formal and Informal Reasoning

• Reasoning can be formal or informal
  – most professionals reason informally (in their head)

• We will teach formal reasoning because
  1. It’s teachable
     informal reasoning = formal reasoning concepts + intuition
     intuition is built up by years of practice
  2. It’s necessary for the hardest problems
     everyone needs the formal toolkit for the hardest problems

• Doesn’t matter to users which you use
  – does matter that you thought through every input
Practicing Reasoning

• Do not “just try things until the tests pass”
  – not a useful skill... AI can do that even faster

• We will tried to make that hard
  – will reduce immediate feedback as course progresses
  – HW9 will have no immediate feedback

• But this is mainly up to you
  – points you get from passing tests don’t get you a job
  – reasoning skill you get by practicing is what matters
Other Properties of High-Quality Code

• Professionals are expected to write high-quality code

• Correctness is the most important part of quality
  – users hate products that do not work properly

• Also includes the following
  – easy to understand
  – easy to change
  – modular
    will also discuss these
AI does not write high-quality code
(not easy to change, easy to understand, or modular)
Other Properties of High-Quality Code

• Note that list did not include **efficiency**

• **We will focus on correctness**
  – a prerequisite for efficiency
    speed doesn’t matter if the code is not correct
  – other classes give plenty of attention to efficiency

• **General rules about programmers (50+ years of evidence):**
  – overestimate the importance of efficiency
  – underestimate the difficulty of correctness
“Programmers overestimate the importance of efficiency and underestimate the difficulty of correctness.”

— Class slogan #3
Will Focus on Timeless Skills

• Focus our time on skills that will be useful 10+ years on...

• Not specific languages or libraries
  – specific knowledge is only impressive to junior programmers
    you will know 3-5 languages by the time you graduate!
    you will not be impressed by someone who knows 1 more
  – AI knows how to write a loop in every language and how to call
    every well-known function in every library
    do not expect to be paid for this knowledge

• Reasoning has proven to be the core skill of programming
  – useful for as long as humans have written code
  – it is language- and library-independent
We Will Ask You to Write Code Differently

• Our goal is not to teach you to write code that looks exactly like what you will see in industry
  – nor is it to use the libraries most common in industry
    the most popular languages and libraries change all the time

• Our goal is to teach you to think through your code and to understand how all the parts work

• That is best served by writing slowly and carefully

• We will force that by
  1. changing programming languages to something unfamiliar
  2. having unusual coding conventions at times
Homework

• CSE 331 is a **hard** class
  – because reasoning & debugging are hard!

• Most of the work is done **outside of class**
  – university policy is 2 hours per hour of class time
  – plan for 8 hours per week, but...

• Wide variation in time required
  – some students will average 10-15 hours
    but this is not expected!
    be sure to get help if you are averaging over 15 hours
Quiz Sections

• Get an ungraded attempt at solving HW-like problems
  – extremely beneficial to student success...

![Graph showing percent achieving each score for students with 1+ absences vs. no absences.](chart.png)
Quiz Sections

• Get an ungraded attempt at solving HW-like problems
  – extremely beneficial to student success

• Plan to attend all quarter

• If you are unable to attend, can submit online
  – submit solutions to all worksheet problems by 11pm

• Participation is not required, but non-participation is interpreted as confidence that you do not need extra help
  – specifically, that you do not need to attend office hours
  – OH time is the most limited resource in the course, so it will be restricted to those who attended that week’s section
Late Days

• 24 hour grace period per assignment
  – don’t need to ask, you can use the grace period automatically
  – i.e., you can turn in each assignment 1 day late! yay!!!

• To go over this limit, you must talk to the instructor

• Plan to complete assignments on time
  – schedule is set up to be done on the due date
  – save “grace period” for emergencies, avoid the snowball effect!
Exams

There are none! 😊
Advice

• Start homework assignments early
  – wide variation in the time required
  – never know how long debugging will take!

• Use the message board whenever possible
  – will get an answer promptly (during working hours)

• Do not skip class to work on homework
More Advice

• Start homework assignments early!

• Make sure you understand how lectures apply
  – seeing no connection to lecture is a giant red flag

• Focus on understanding, not points
  – understanding, not points, will not get you a job
  – losing points is the best reminder to review later
“Engineers are paid to think and understand.”
— Class slogan #1

“Reasoning is not optional: either reason up front or debug and then reason.”
— Class slogan #2

“Programmers overestimate the importance of efficiency and underestimate the difficulty of correctness.”
— Class slogan #3