CS 3110

Introduction to 3110

Nate Foster
(Guest Lecture: Adrian Sampson)
Spring 2020

Programming is not hard

Programming well is very hard

Folklore:

10x

variation in professional programmer productivity

[Grant and Sackman, 1967]: 28x
[Prechelt 1999]: 2-4x

The Goal of 3110

Become a better programmer
though study of
programming languages

Programming Languages

Java is to Programming Languages
as
Japanese is to Linguistics

Programming Languages: Language design, implementation, semantics, compilers, interpreters, runtime systems, programming methodology, testing, verification, security, reliability…

Adjacent to **Software Engineering** in the CS family tree.

Questions we'll pursue

- How do you write code for and with other people?
- How do you know your code is correct?
- How do you describe and implement a programming language?

Tasks we'll pursue

Practice of programming: read and write lots of code

7 programming assignments:
first 4 individual, latter 3 partners recommended

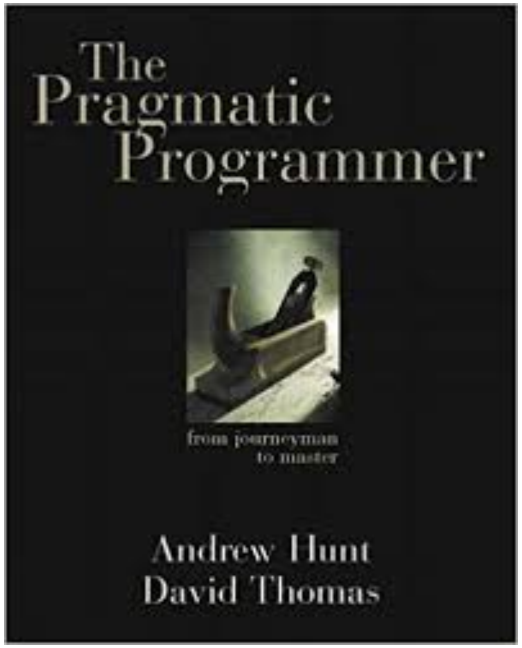
Tasks we'll pursue

Practice of programming: coding as a team

team project, agile development, 4 milestones
3 team members of your choice from your discussion section

Tasks we'll pursue

Philososphy of programming: written reflections



Six written responses to *The Pragmatic Programmer* reflecting on your experience with coding and how you are growing as a programmer

Tasks we'll pursue

Learning a functional language

Why? What does that even mean?

What is a functional language?

A functional language:

- defines computations as mathematical functions
- avoids mutable state

State: the information maintained by a computation

Mutable: can be changed (antonym: *immutable*)

Mutability

The fantasy of mutability:

- It's easy to reason about: the machine does this, then this...

The reality of mutability:

- Machines are good at complicated manipulation of state
- Humans are not good at understanding it!

Mutability breaks *referential transparency:* ability to replace expression with its value without affecting result of computation

Imperative programming

Commands specify how to compute by destructively changing state:

```
x = x+1;
a[i] = 42;
p.next = p.next.next;
```

Functions/methods have **side effects**:

```
int x = 0;
int incr_x() {
  x++;
  return x;
}
```

Functional programming

Expressions specify what to compute

- Variables never change value
- Functions never have side effects

The reality of immutability:

- No need to think about state
- Powerful ways to build correct programs

Why study functional programming?

1. Functional languages teach you that programming transcends programming in a language (assuming you you have only programmed in imperative languages)
2. Functional languages predict the future
3. (Functional languages are *sometimes* used in industry)
4. Functional languages are elegant

Alan J. Perlis

1922-1990

“A language that doesn't affect the way you think about programming is not worth knowing.”

First recipient of the Turing Award

for his “influence in the area of advanced programming techniques and compiler construction”

Analogy: studying a foreign language

- Learn about another culture; incorporate aspects into your own life
- Shed preconceptions and prejudices about others
- Understand your native language better

Functional languages predict the future

- Garbage collection
  Java [1995], LISP [1958]
- Generics
  Java 5 [2004], ML [1990]
- Higher-order functions
  C#3.0 [2007], Java 8 [2014], LISP [1958]
- Type inference
  C++11 [2011], Java 7 [2011] and 8, ML [1990]
- **What's next?**

Functional languages in the real world

- Java 8 ORACLE
- F#, C# 3.0, LINQ Microsoft
- Scala twitter foursquare LinkedIn
- Haskell facebook BARCLAYS at&t
- Erlang facebook amazon T · · Mobile ·
- OCaml facebook Bloomberg CITRIX

  https://ocaml.org/learn/companies.html Jane Street

...but Cornell CS (et al.) require functional programming for your *education,* not to get you a job

Functional languages are elegant

Neat Stylish

Dignified Refined

Simple

Effective Graceful

Precise Consistent

Tasteful

Elegant

Neat Stylish

Beautiful

Precise Consistent

Tasteful

Do aesthetics matter?

YES!

Who reads code?

- Machines
- Humans

- Elegant code is easier to read and maintain
- Elegant code might (not) be easier to write

OCaml

A pretty good language for writing beautiful programs

O = Objective, Caml=not important
ML is a family of languages; originally the “meta-language” for a tool

OCaml is awesome

- Immutable programming
  - Variable's values cannot destructively be changed; makes reasoning about program easier!
- Algebraic datatypes and pattern matching
  - Makes definition and manipulation of complex data structures easy to express
- First-class functions
  - Functions can be passed around like ordinary values
- Static type-checking
  - Reduce number of run-time errors
- Automatic type inference
  - No burden to write down types of every single variable
- Parametric polymorphism
  - Enables construction of abstractions that work across many data types
- Garbage collection
  - Automated memory management eliminates many run-time errors
- Modules
  - Advanced system for structuring large systems

But no language is perfect…

Languages are tools

Languages are tools

- There's no universally perfect tool
- There's no universally perfect language
- **OCaml is good for this course** because:
  - good mix of functional & imperative features
  - relatively easy to reason about meaning of programs
- **But OCaml isn't perfect**
  - there will be features you miss from language X
  - there will be annoyances based on your expectations
  - keep an open mind, try to have fun

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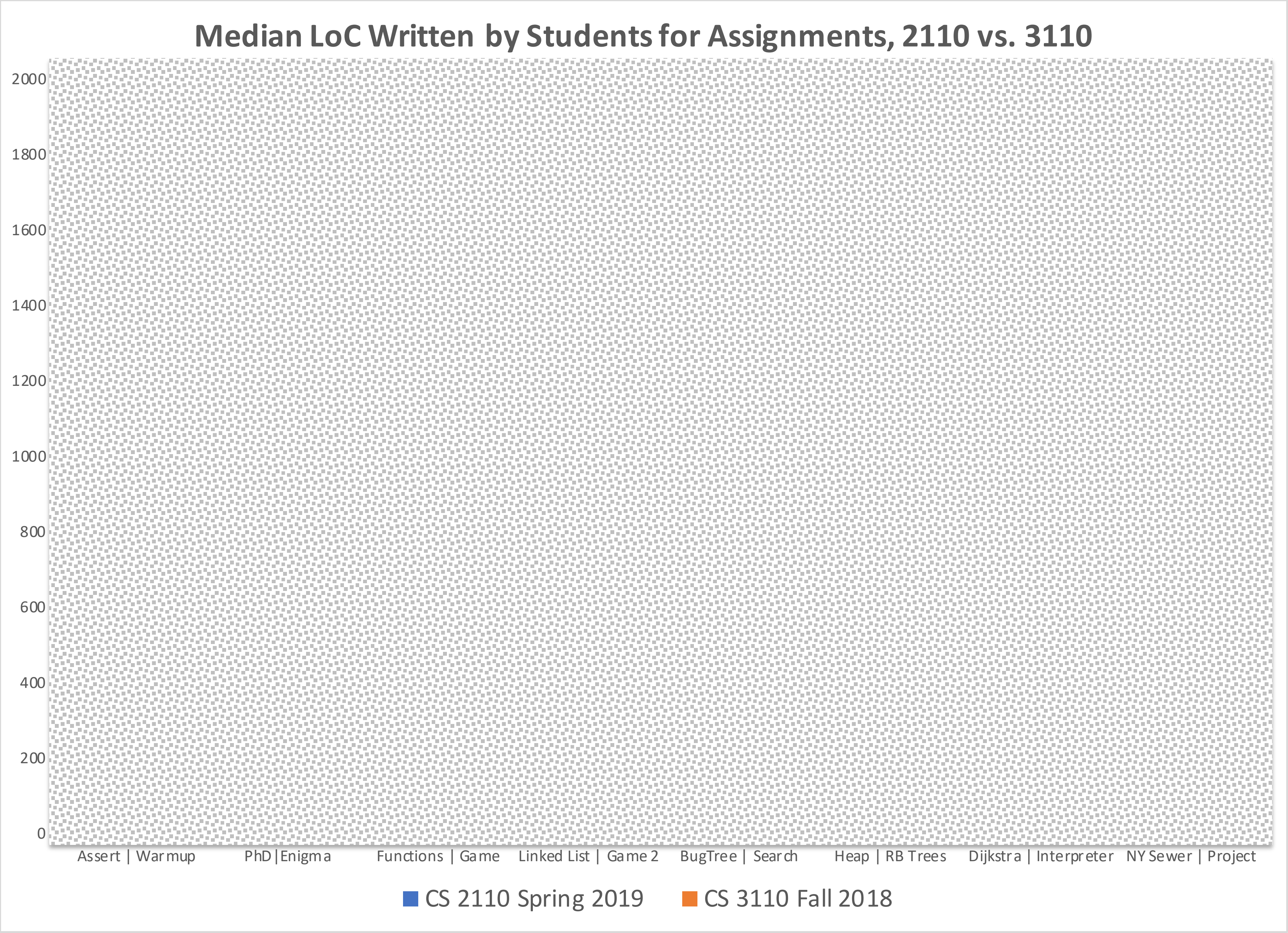
Why are

you

here?

CS 2110	vs.	CS 3110
3 credits		4 credits
Engineers		CS majors & minors
Intro		Core

Lines of code…



Median LoC Written by Students for Assignments, 2110 vs. 3110

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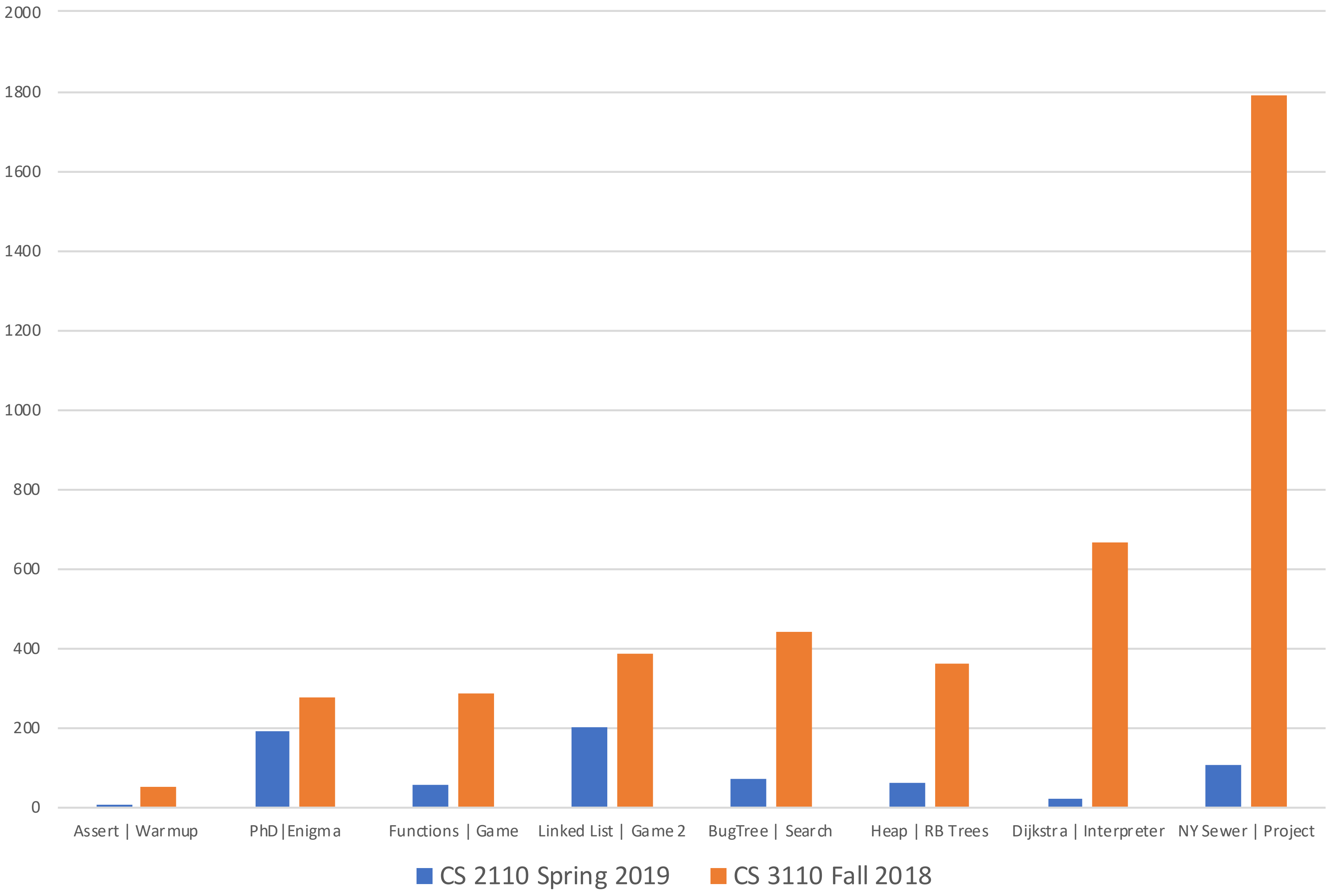


LOGISTICS

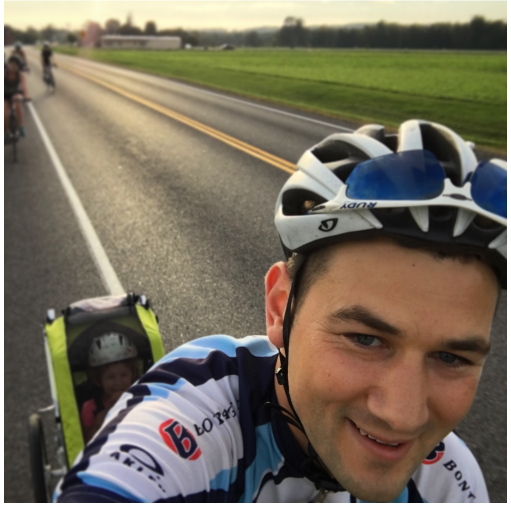
Course website

cs3110.org

or

https://www.cs.cornell.edu/courses/cs3110/2019fa/

Course staff



Instructor: Nate Foster

- PhD at UPenn
- At Cornell since 2010
- Research: programming languages & networking
- Call him "Nate" in this course, or "Dr. Foster" if you're not into the whole brevity thing

Course staff

TAs and consultants: 62 at last count

…approx. 6-to-1 student-to-instructor ratio

Over 160 person-hours of consulting/office hours scheduled each week

Campuswire

Please prefer Campuswire to email

Upcoming events

- [now] Pick up a 1-page summary on your way out
- [Thursday lecture] Bring iClicker
- [Thursday afternoon] Consulting hours start
- [Thursday] A0 released
- [Thursday/Monday] Discussion sections start

…why are you still here? Get to work! ☺

THIS IS 3110