Introduction to 3110

Prof. Clarkson
Fall 2015

Today's music: Prelude from Final Fantasy VII
by Nobuo Uematsu (remastered by Sean Schafianski)
Welcome!

• Programming isn’t hard
• Programming **well** is **very** hard
  – High variance among professionals’ productivity: 10x or more
  – Studying functional programming will make you a better programmer, but it requires an open mind
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)
Functional vs. imperative

Functional languages:
• Higher level of abstraction
• Easier to develop robust software
• Immutable state: easier to reason about software

Imperative languages:
• Lower level of abstraction
• Harder to develop robust software
• Mutable state: harder to reason about software

You don’t have to believe me now. If you master a functional language, you will. 😊
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**:

```cpp
int wheels(Vehicle v) {
    v.size++;  
    return v.numWheels;
}
```
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
  - In math, if $f(x) = y$, then you can substitute $y$ anywhere you see $f(x)$
  - In imperative languages, you cannot: $f$ might have side effects, so computing $f(x)$ at time $t$ might result in different value than at time $t'$

...mutable programming is not well-suited to building correct code!
Mutability

The fantasy of mutability:
• There is a single state
• The computer does one thing at a time

The reality of mutability:
• There is no single state
  – Programs have many threads, spread across many cores, spread across many processors, spread across many computers… each with its own view of memory
• There is no single program
  – Most applications do many things at one time

...mutable programming is not well-suited to modern computing!
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 and concurrent programs
Why study functional programming?

1. Functional languages teach you that programming **transcends** programming in a language (assuming 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**
Why study functional programming?

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4. Functional languages are elegant
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
Alan J. Perlis

“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”

1922-1990
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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?**
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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

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

"Education is what remains after one has forgotten everything one learned in school."

1879-1955
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Elegant

Beautiful

Neat  Stylish

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 because of...**

- **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
A GLIMPSE OF OCAML...
LOGISTICS
Course website

http://www.cs.cornell.edu/Courses/cs3110/2015fa/

- **Full syllabus** *(required reading)*
- Lecture slides
  - Typically go live within 24 hours after lecture
  - Supplement, do not replace, attendance
- Recitation notes
Course staff

Instructor: Michael Clarkson
- PhD 2010 Cornell University
- Research areas: security and programming languages
- I go by “Prof. Clarkson” in this course

Recitation instructor: Mike George
- PhD ABD Cornell University

TAs and consultants: 46 at last count
- Course administrator (“head TA”): Remy Jette (rcj57)
Course meetings

• **Lectures:** TR 10:10-11:00 am
  – attendance is semi-mandatory, about 1% of grade, measured by i>clicker
  – go buy an i>clicker and bring it on Thursday

• **Recitations:** mostly MW
  – Attendance is expected
  – TR sections are effectively MW delayed one day
  – You may attend any, regardless of registration, subject to room capacity; please pick one and stick with it
  – bring your laptop with OCaml installed

• **Consulting:** coverage nearly every day
Email

• If it's about **content**, post a message on Piazza
  – Messages restricted only to me probably will get lost

• If it's about your own **personal logistics**, send email to **cs3110-instructors-L@cornell.edu**

• But better than that...come talk to me in person!
Academic integrity

• You are bound by the Cornell Code of Academic Integrity, the CS Department Code of Academic Integrity, and the CS 1110 Explanation of Academic Integrity
  – All linked from course website
  – You are responsible for understanding them
• I use MOSS to detect plagiarism; it works
• If you have a question about what is or is not allowed, please ask
• If you fear you have committed a violation, tell me before grading commences
Enrollment

• The course is at fire-code capacity
  – I cannot add any students
  – You will have to wait until someone drops
  – No auditors allowed this semester
• CS 3110 will be taught in the spring and historically is never full
Your TODO list for tonight

1. read the syllabus
2. buy an i>clicker
3. login to CMS and Piazza
   – linked from course website
   – trouble? contact course administrator with your full name and NetID
4. install OCaml
   – we provide a virtual machine on course website
   – will be used in recitation tomorrow: download tonight
   – trouble? post on Piazza or see a consultant
Upcoming events

• [Tue-Thur pm] Drop by my office in the afternoon if you need something immediately
• [Wednesday] Recitations begin (none today)
• [Wednesday pm] Consulting hours start; check calendar on course website for times and places
• [Thursday am] i>clickers start in lecture

...why are you still here? Get to work! 😊

THIS IS 3110