

Computing Science (CMPUT) 325

Nonprocedural Programming

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Winter 2016

Topics for Today - Jan 19

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- Quiz 1 review ~~on Thursday~~ **today**
- Quiz 2 will open today
- Background knowledge - Which functional Languages and Lisp dialects are there?
- Symbolic expressions (s-expressions, s-expr) in Lisp
- Machine representation of s-expressions

Functional Programming Languages

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- Many dozens of functional languages exist
- Lisp is one of the oldest, and branched into many dialects
- We use Common Lisp which has an ANSI standard

History of Functional Programming

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- Lambda calculus: developed by Alonzo Church, mathematician and logician, in 1930s
 - You will meet him again, e.g. Church-Turing thesis, Church-Rosser Theorem
- Formal system for expressing computation
- Main concepts: function abstraction, function application, variable binding, substitution
- Equivalent in expressive power to Turing machines
- A minimalistic, theoretical basis for functional programming
- We will study it later in this part of the course

LISP History

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- LISP: stands for LISt Processor
- Developed by John McCarthy in 1958
- “second-oldest language in widespread use today”
- Common Lisp: current ANSI standard from 1994, revised 2004
- Many important dialects - I will review a few
- Big general purpose language, we focus on the “pure functional” subset

Scheme

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- Major dialect of Lisp, different from Common Lisp
- Developed in the 70's by Steele and Sussman at MIT
- Also has official IEEE standard, but many variants exist
- Used in many schools, sometimes as first programming language
- Used e.g. in GIMP graphics editor, Final Fantasy, Google App Inventor
- Often used as a scripting language for extending programs
- Implementations e.g. MIT/GNU Scheme, Stalin compiler, Kawa compiler to JVM

Clojure

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- Lisp dialect, based on Common Lisp
- Focus on multithreaded programming, immutable data
- Runs on the Java virtual machine (JVM)
- Adds a **type system**
- Used in production code by large companies such as Walmart
- See `clojure.org`

Emacs Lisp

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- By Richard Stallman (of FSF, GNU, gcc fame)
- Used in GNU emacs and XEmacs editors
 - Small core with primitives written in C
 - Everything else is in Lisp
- Used to customize and extend emacs
- Also used as a scripting language, e.g. directly from command line

Hy (or Hylang)

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- Lisp dialect, integrated with Python
- “Lisp front end to Python’s abstract syntax tree (AST)”
- Lisp data compiled into AST
- Can use Python libraries with Lisp in this way
- See `hylang.org`

Some Other Functional Languages

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- Haskell
- ML, Caml, OCaml and F#
- APL
- Traditional languages with functional programming elements

Haskell

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- Pure functional language - no side effects
- Strong static typing (unlike Lisp)
- Lazy evaluation
- GHC - open source interpreter and compiler
- See `haskell.org`

ML, Caml, OCaml and F#

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- “Impure” functional language, allows side effects
- Eager evaluation - evaluates subexpressions
- ML developed from 1970s
- F# by Microsoft, part of CLI, .NET and Visual Studio, strongly typed
- Caml, OCaml based on ML, popular in theorem proving community

APL and J

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- Developed by Ken Iverson from 1960s
 - Iverson is from Camrose, Alberta and won the Turing Award in 1979
- Very concise language based on functions and **operators** (like higher-order functions)
- Central data type is array and higher-dimensional arrays (matrices etc)
- Very powerful built-in functions
- Special character set, most functions are a single symbol

Traditional languages with functional programming elements

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- C++11, C++14
- Java 8
- Javascript, e.g. functions as first class objects, lambda functions
- Python
- There are recent books on “Functional Programming using x ” for all programming languages x above...

Summary

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- Brief Overview of functional programming (FP) languages
- Lambda calculus as formal basis
- History of Lisp and dialects
- Some other popular and/or influential functional languages
- Recent trend: add FP features to other languages