



15-292 History of Computing

Partial History of Programming Languages and Artificial Intelligence



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The first assembler



- Assembler - a computer program for translating assembly language into executable machine code
 - Example: `ADD R1, R2, R3 0110000100100011`
- The EDSAC programming system was based on a subroutine library
 - commonly used functions that could be used to build all sorts of more complex programs
 - the first version, Initial Orders 1, was devised by David Wheeler, then a research student, in 1949
- Team published “The Preparation of Programs for an Electronic Digital Computer”
 - the only programming textbook then available
 - computers today still use Cambridge model for subroutines library

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The first compiler



- A compiler is a computer program that translates a computer program written in one computer language (the *source* language) into a program written in another computer language (the *target* language).
 - Typically, the target language is assembly language
 - Assembler may then translate assembly language into machine code
 - Machine code are directions a computer can understand on the lowest hardware level (1s & 0s)
- A-0 is a programming language for the UNIVAC I or II, using three-address code instructions for solving mathematical problems.
- A-0 was the first language for which a compiler was developed.
 - It was produced by Grace Hopper's team at Remington Rand in 1952
 - Grace Hopper had previously been a programmer for the Harvard Mark machines
 - One of U.S.'s first programmers
 - She found a moth in the Mark I, which was causing errors, and called it a computer "bug"

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FORTRAN (1957)



- First successful high-level programming language
 - Code more readable and understandable by humans
- Developed by John Bachus at IBM
 - Stands for: FORmula TRANslation
 - Started development in 1954
 - Released in 1957, is still in use today
- A key goal of FORTRAN was efficiency, although portability was also a key issue
 - automatic programming that would be as good as human programming of assembly code
 - resulted in making programs 90% as good as humans
- Programs that took weeks to write could now take hours
- 1961 – First FORTRAN programming textbook
 - Universities began teaching it in undergrad programs
- Provided standard exchange of programs despite different computers
- Became the standard for scientific applications

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FORTRAN



```

REAL SUM6,SUM7,SUM8,DIF6,DIF7,DIF8,SUMINF
OPEN(6,FILE='PRN')
SUM6=.9*(1.-0.1**6)/0.9
SUM7=.9*(1.-0.1**7)/0.9
SUM8=.9*(1.-0.1**8)/0.9
*****COMPUTER SUM OF INFINITE TERMS
SUMINF=0.9/(1.0-0.1)
*****COMPUTE DIFFERENCES BETWEEN FINITE & INFINITE SUMS
DIF6 = SUMINF - SUM6
DIF7 = SUMINF - SUM7
DIF8 = SUMINF - SUM8
WRITE(6,*) 'INFINITE SUM = ', SUMINF
WRITE(6,*) 'SUM6 = ', SUM6, '    INFINITE SUM - SUM6 = ', DIF6
WRITE(6,*) 'SUM7 = ', SUM7, '    INFINITE SUM - SUM7 = ', DIF7
WRITE(6,*) 'SUM8 = ', SUM8, '    INFINITE SUM - SUM8 = ', DIF8
STOP
END

```

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COBOL (1960)



- Stands for: COmmon Business-Oriented Language
- COBOL was initially created in 1959 (and released in 1960 as Cobol 60) by a group of computer manufacturers and government agencies
 - US Government wanted a standard for its computers
- One goal of COBOL's design was for it to be readable by managers, so the syntax had very much of an English-like flavor.
 - The specifications were to a great extent inspired by the FLOW-MATIC language invented by Grace Hopper
 - She then promoted COBOL's use
- Became the standard for business applications
 - Still used in business applications today.
- 90% of applications over next 20 years were written in either COBOL or FORTRAN
 - Old programmers came out of hiding for Y2K

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COBOL



```

000100 ID DIVISION.
000200 PROGRAM-ID.  ACCEPT1.
000300 DATA DIVISION.
000400 WORKING-STORAGE SECTION.
000500 01 WS-FIRST-NUMBER PIC 9(3) .
000600 01 WS-SECOND-NUMBER PIC 9(3) .
000700 01 WS-TOTAL PIC ZZZ9.
000800*
000900 PROCEDURE DIVISION.
001000 0000-MAINLINE.
001100 DISPLAY 'ENTER A NUMBER: ' .
001200 ACCEPT WS-FIRST-NUMBER.
001300*
001400 DISPLAY 'ANOTHER NUMBER: ' .
001500 ACCEPT WS-SECOND-NUMBER.
001600*
001700 COMPUTE WS-TOTAL = WS-FIRST-NUMBER + WS-SECOND-NUMBER.
001800 DISPLAY 'THE TOTAL IS: ', WS-TOTAL.
001900 STOP RUN.

```

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LISP (1958)



- Developed by John McCarthy at MIT
- Stands for: LISt Processing
 - Designed for symbolic processing
 - Introduced symbolic computation and automatic memory management
 - Two basic data types: atoms and lists
 - A list is a finite sequence of elements, where each element is either an atom or a list.
 - An atom is either a number or a symbol.
- Used extensively for Artificial Intelligence applications



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LISP

```
(defun last1 (lst)
  (car (last lst)))
(defun single (lst)
  (and (consp lst) (not (cdr lst))))
(defun append1 (lst obj)
  (append lst (list obj)))
(defun longer (x y)
  (labels ((compare (x y)
            (and (consp x)
                 (or (null y)
                     (compare (cdr x) (cdr y))))))
    (if (and (listp x) (listp y))
        (compare x y)
        (> (length x) (length y)))))
```

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Living & Dead Languages

- Hundreds of programming languages popped up in the 1960s, most quickly disappeared
- Some dead:
 - JOVIAL, SNOBOL, Simula-67, RPG, ALGOL, PL/1, and many, many more
- Some still kicking:
 - LISP (1957)
 - BASIC (1964)
 - Pascal (1970)
 - Prolog (1972)
 - And of course, C (1973)

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ALGOL-60 (1960)



- Created mainly in Europe by a committee of computer scientists
 - John Backus and Peter Naur both served on the committee which created it
 - Desired an IBM-independent standard
- Stands for: ALGOritmic Language
- Primarily intended to provide a mechanism for expressing algorithms uniformly regardless of hardware
- The first report on Algol was issued in 1958,
 - Specifications revised in 1959 and 1960 (and later in 1968)
- The language itself was not a success, but it was an influence on other successful languages
 - A primary ancestor of Pascal and C.
- It introduced block structure, compound statements, recursive procedure calls, nested if statements, loops, and arbitrary length identifiers

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BASIC (1964)



- Created by John Kemeny and Thomas Kurtz at Dartmouth College
- Stands for: Beginner's All-purpose Symbolic Instruction Code
 - one of the first languages designed for use on a time-sharing system
 - one of the first languages designed for beginners
- Variants like Visual BASIC still used today by Microsoft.

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Pascal (1970)



- Developed by Niklaus Wirth in an effort to make structured programming easier for a compiler to process.
- Based on Algol
 - Named in honor of mathematician and philosopher Blaise Pascal
- Wirth also developed Modula-2 and Oberon, languages similar to Pascal which also support object-oriented programming.
- Pascal was the most popular programming language for teaching computer programming in the 1970s and 1980s

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Prolog (1972)



- Created by Alain Colmerauer and Phillipe Roussel of the University of Aix-Marseille and Robert Kowalski of the University of Edinburgh
- Stands for: PROgramming in LOGic.
- Prolog is the leading *logical* programming language.
 - used in artificial intelligence programs, computer linguistics, and theorem proving.

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Prolog



```

parents(william, diana, charles).
parents(henry, diana, charles).
parents(charles, elizabeth, philip).
parents(diana, frances, edward).
parents(anne, elizabeth, philip).
parents(andrew, elizabeth, philip).
parents(edward, elizabeth, philip).
married(diana, charles).
married(elizabeth, philip).
married(frances, edward).
married(anne, mark).
parent(C,M) <= parents(C,M,D).
parent(C,D) <= parents(C,M,D).
sibling(X,Y) <= parents(X,M,D) and parents(Y,M,D).

```

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C (1973)



- Developed by Ken Thompson and Dennis Ritchie at AT&T Bell Labs for use on the UNIX operating system.
 - now used on practically every operating system
 - popular language for writing system software
- Features:
 - An extremely simple core language, with non-essential functionality provided by a standardized set of library routines.
 - Low-level access to computer memory via the use of pointers.
- C ancestors: C++, C#, Java
- We'll see more when we talk more about software

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C++ (C with Classes)



- Bjarne Stroustrup began work on C with Classes in 1979, renamed C++ in 1982.
 - Developed at AT&T Bell Laboratories.
 - Added features of Simula to C.
 - Contained basic object-oriented features:
 - classes (with data encapsulation), derived classes, virtual functions and operator overloading
 - In 1989, release 2.0 added more features:
 - multiple inheritance, abstract classes, static member functions, and protected members
 - Standard Template Library (STL) official in 1995

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Java

Naughton (L)
and Gosling (R)



- Created by Patrick Naughton and James Gosling at Sun Microsystems
 - Originally designed for small consumer devices
 - Original project code name: Green
 - Main feature: Code is generated for a virtual machine that can run on any computer with an appropriate interpreter
 - Original name of the language: Oak
 - First project from the Green team: Star7 (*7), an extremely intelligent remote control in 1992

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Java (cont'd)



"Duke"



- Java finds its application niche in the Internet
 - HotJava Browser and Applets
 - Java 1.0 debuts in May 1995
 - The course language is small with an API (Application Programmers Interface) supplying many additional operations

Version	Classes & Interfaces	Methods & Fields
1.0	212	2125
1.1	504	5478
1.2	1781	20935
1.3	2130	23901
1.4	3020	32138

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Python



- Created by Guido van Rossum in the late 1980s.
 - "Benevolent Dictator For Life"
- Allows programming in multiple paradigms: object-oriented, structured, functional
- Uses dynamic typing and garbage collection
- The Zen of Python:
 - Beautiful is better than ugly.
 - Explicit is better than implicit.
 - Simple is better than complex.
 - Complex is better than complicated.
 - Readability counts.

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Artificial Intelligence

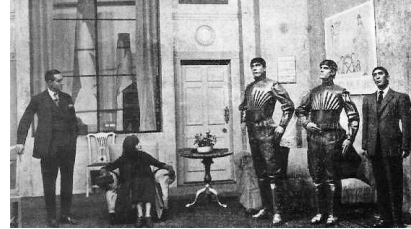


*Frankenstein, or
The Modern Prometheus*
by Mary Shelly (1820)

Early vision of
intelligent machines...



The Flute Player (automaton)
by Innocenzo Manzetti (1840)



Rossum's Universal Robots
a play by Karel Capek (1920)
<http://preprints.readingroo.ms/RUR/rur.pdf>

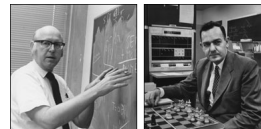
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AI: Gestation (1943-1956)



- Warren McCulloch and Walter Pitts (1943)
 - Proposed a model of artificial neurons
 - Donald Hebb (1949) demonstrates updating rule for modifying connection strengths
- Shannon and Turing - chess programs (50s)
- Minsky and Edmonds - first neural network computer
- John McCarthy - organized two month workshop in 1956
 - Birth of the name "artificial intelligence" to the field
 - Allen Newell and Herb Simon – demonstrated the Logic Theorist program
 - Proved all of the theorems in Chap 2 of *Principia Mathematica*



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AI: Great Expectations (1952-69)



- Newell and Simon - General Problem Solver (1957) - designed to imitate human problem-solving protocols
- Herbert Gelernter (IBM, 1959) - Geometry Theorem Prover
- McCarthy - wrote Programs with Common Sense (1958) introducing Advice Taker, first “complete” AI system - used search through axioms to solve problems
- Marvin Minsky 1960s - studied microwords (limited domain knowledge to specific problems)
 - integration, geometry, question answerer, algebra, block worlds



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AI: Dose of Reality (1966-74)



- Claims of future successes were wildly optimistic
 - Simon predicted in 1958 that in ten years, a computer would be chess champion and an important math theorem would be proven by computer.
 - ELIZA (1965) by Weizenbaum – program “simulating” a psychotherapist using text matching and manipulation
- Machine evolution (Friedberg 1959) - making small tweaks to programs to find stronger (better) programs produced no useful outcomes
- Failure to consider the combinatorial nature of most AI problems
 - Faster hardware did not yield improvements

```

Welcome to
EEEEEE LL      IIII 2222222  AAAA
EE      LL      II   22  AA  AA
EEEEEE LL      II   222  AAAAAA
EE      LL      II   22  AA  AA
EEEEEE LLLLLL IIII 2222222  AA  AA

Eliza is a mock Rogerian psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation by Norbert Landsteiner 2005.

ELIZA: Is something troubling you ?
YOU:  Men are all alike.
ELIZA: What is the connection, do you suppose ?
YOU:  They're always bugging us about something or other.
ELIZA: Can you think of a specific example ?

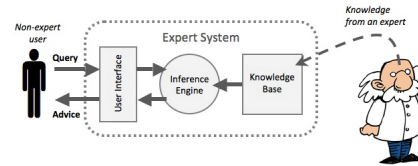
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AI: Knowledge-Based Systems (1969-79)

- New methodology of **expert systems** begins to emerge



- DENDRAL (1969) - inferred molecular structure from data provided by a mass spectrometer
 - Contained a large number of special purpose rules based on knowledge from chemists
- MYCIN - expert system to diagnose blood infections
- Natural language processing emerges
 - LUNAR (1973) - allowed geologists to ask questions in English about rock samples brought back from the moon
- Knowledge representation languages: Prolog, PLANNER, Minsky's frames

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AI: An Industry Forms (1980-88)

- R1 - first commercial expert system developed by Digital Equipment Corp. (1981)
 - Helped configure orders for new computer systems, helping the company save \$40M/year by 1986
- "Fifth Generation Project" - 10 year plan in Japan to build intelligent computers running Prolog
- US and Britain respond by funding research into advanced chip design and human-interface research.
 - Lisp Machines - optimized to run Lisp programs



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AI: From Rules to Mathematics (1986-present)



- Reinvention of the Neural Network back propagation algorithm (mid 1980s)
 - Led to application to many learning problems in computer science and psychology
- Hidden Markov Models (HMMs) become dominant in speech technology
- Belief Networks utilized probabilistic analysis to deal with uncertain information
- Machine Learning - methods utilizing statistics and large data sets to predict outcomes
 - Starts to flourish in the 1990s

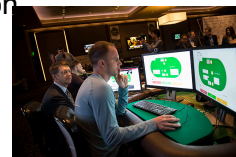
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Machine Intelligence in the 2000s



- iRobot's Roomba (2002)
- DARPA Grand Challenge (2004)
 - CMU wins Urban Challenge in 2007 led by "Red" Whittaker
- Checkers is solved (2007)
- IBM Watson defeats Jeopardy! champions (2011)
 - features CMU researchers working with IBM
- Natural Language response (2011) - Siri, etc.
- DeepFace - Facebook (2014) - facial recognition
- Sibyl - Google (2015) - predicts user behavior
- Libratus plays Texas Hold 'Em (2017)
 - led by Tuomas Sandholm of CMU



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