CS 100: Prelude

Chris Kauffman

Week 1-1
The T-Shirt Launcher

Gosling wishes to fire a T-Shirt into the hands of Ellison on Stage.

- Distance from Gosling to Ellison: 80 meters
- Ellison’s elevation: 2 meters
- T-shirt launcher firing speed: 20 meters/second
- Launch angle: ???
Calculating a Trajectory

Gosling is awesome and remembers that the firing angle can be calculated using the following formula

\[ \theta = \arctan \left( \frac{v^2 \pm \sqrt{v^4 - g(gx^2 + 2yv^2)}}{gx} \right) \]

- \( v \) is firing speed: 20 meters/second
- \( g \) is the gravitational constant: 9.8 m/s\(^2\)
- \( x \) is the target distance: 80 meters
- \( y \) is the target elevation: 2 meters

How would you solve the firing angle \( \theta \)?
Typical Solution

- Grab a calculator/computer/table of sqrt/arctan values
- Plug in numbers $v, g, x, y$ which are given
- Computer numeric answer for the angle $\theta$
- *Fire ze missiles* (er t-shirt)
Solving for the Firing Angle

Computer spreadsheets and other software are also frequently used to calculate square roots.

▶ Wikip: Square Root

The computation of trigonometric functions is a complicated subject, which can today be avoided by most people because of the widespread availability of computers...

▶ Wikip: Trigonometric Functions

Consider

1. Sometimes you don’t have a fancy calculator
2. Is it impossible at those times to compute a square root?
3. Important: How do the machines do it anyway?
The Babylonian Algorithm to computer the square root of \( S \)

- Initialize: Set \( x \) to a guess
- Repeat
  - Calculate \( x_{\text{next}} = \frac{1}{2} \left( x + \frac{S}{x} \right) \)
  - Set \( x \) to be \( x_{\text{next}} \)
  - If \( x^2 \) is close enough to \( S \), quit

Let’s see if it works, try calculating \( \sqrt{18} \)
Computing $\sqrt{18}$

\begin{verbatim}
s = 18    # Find my square root
x = 4     # A guess
# Repeate these steps
xnext = (1/2) * (x + 18 / x)
x = xnext

x
4.25000000000000000000
x^2 - 18
.06250000000000000000
# Pretty close, but can we get closer?

xnext = (1/2) * (x + 18 / x)
x = xnext
4.24264705882352941176
x = xnext
x^2 - 18
.00005406574394463663
# That's close enough for me
\end{verbatim}
al-Khwa-what?

Abū ‘Abdallāh Muḥammad ibn Mūsā al-Khwārizmī (780-850 AD)

- Say that 5 times fast
- Well, algorithm is close enough

In the twelfth century, Latin translations of his work on the Indian numerals introduced the decimal positional number system to the Western world. His Compendious Book on Calculation by Completion and Balancing presented the first systematic solution of linear and quadratic equations in Arabic. In Renaissance Europe, he was considered the original inventor of algebra, although it is now known that his work is based on older Indian or Greek sources.

- Wikipedia
A series of well-defined steps that guarantee you get a correct answer.

- Something needs to do the steps
- That something usually has some primitive operations
- That something is frequently called a computer
- Computers take many forms
Algorithms you probably know

- Add 127 and 314
- Draw a 5-pointed star
- Type the words in this image

Which of these are computers good at?

- Stand on one foot
- Classify these pictures as a cat or a dog
Rise of the Machines?

Computers can execute algorithms fast which means
- They can add/subtract/multiply/divide numbers very fast
- Can draw cool pictures and produce stunning graphics

But computers are only as good as the algorithms that humans plug into them. Lots of things we can do without even thinking about it are hard to program including
- Image processing: what text does this image contain
- Object identification: cat or dog?
- Stability control: standing on one foot

Source: Capital Wired
Back to the Launcher: How about arctan?

A helpful formula

\[ \text{arctan } z = z - \frac{z^3}{3} + \frac{z^5}{5} - \frac{z^7}{7} + \cdots = \sum_{n=0}^{\infty} \frac{(-1)^n z^{2n+1}}{2n+1}; \quad |z| \leq 1 \]

**Construct** an algorithm using this formula to compute \( \text{arctan } z \)

- What specific steps would you go through to compute \( \text{arctan } 0.5 \)?
- Write those steps as instructions another Human can understand
- This is surprisingly difficult...

*Science is what we understand well enough to explain to a computer. Art is everything else we do.* -Donald Knuth
Algorithm

- Initialize A to be input Z
- Initialize COUNT to be 3
- Initialize SIGN to be negative
- Repeat as long as you like
  - Compute

\[ \text{NEXT} = Z^{COUNT} / COUNT \]

- If SIGN is negative
  - Set A to be \( A - \text{NEXT} \)
  - Set SIGN to be positive
- If SIGN is positive
  - Set A to be \( A + \text{NEXT} \)
  - Set SIGN to be negative
- Set COUNT to be COUNT+2

Execution

\[ z = 0.75 \]
\[ a = z \]
\[ a = a - z^3/3 \]
\[ .60937500000000000000 \]
\[ a = a + z^5/5 \]
\[ .65683593750000000000 \]
\[ a = a - z^7/7 \]
\[ .63776681082589285715 \]
\[ a = a + z^9/9 \]
\[ .64610955374581473215 \]

arctan(0.75)
\[ .64350110879328438680 \]
Folks Who had a Similar Problem

WWI and WWII
Artillery: Allies shell Germans, Germans Shell Allies

- No computers
- No electronic calculators
- Very limited mechanical calculators
- How did they know how far to raise the gun?
Artillery Table

German Table: Degrees for given Distance/Elevation

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<th>True Drop</th>
<th>Range (m)</th>
<th>Distance (m)</th>
<th>Height (m)</th>
<th>1/16 deg Change of Point of Impact (m)</th>
<th>Angle of Impact</th>
<th>Velocity (m/s)</th>
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Image Source

"Computers"

Image Source

Computing ARCTAN’s is more fun than a barrel of monkies!
The Original Computers

The First World War required large numbers of human computers. Computers on both sides of the war produced map grids, surveying aids, navigation tables and artillery tables. With the men at war, most of these new computers were women and many were college educated. The British Army established a computing office for women at Girton College. The first female computer hired by the (US) Army in 1918 was Elizabeth Webb Wilson (1898–1975). Wilson was a graduate from George Washington University and had won her school’s mathematics prize.

The Human Computer and the Birth of the Information Age
By David Alan Grier
Archibald edited the journal *MATHEMATICAL TABLES AND OTHER AIDS TO COMPUTATION*. The journal attracted a wide readership *during the Second World War*, when the demand for computers expanded. Near the end of the Second World War, the journal began publishing reports on the *new electronic computing machines*. It published the first reports on the ENIAC and the early Bell Labs computers. A few scientists, such as MIT’s Philip Morse, argued that human computers still had plenty to do in the electronic computer era and in 1954, he organized a large conference for human computers. This conference produced the *final legacy* of the human computer, *THE HANDBOOK OF MATHEMATICAL FUNCTIONS*. The HANDBOOK showed how to calculate most of the higher mathematical functions in common use.

*The Human Computer and the Birth of the Information Age By David Alan Grier*
Today: Spreadsheets are your friend

Tables of mathematical calculations are no sweat

- Write the formula
- Change the input data
- Paste formula, voila!
- But how does the magic happen?
But not all code is so numeric...

Check out http://code.org

- The advanced course here will be your HW2
- Register here: http://studio.code.org/join/WFPGRG and get started
- Learn to program using programming blocks
- Let’s try a couple
Goals for the Course

- Understand basics of how and why computers work
- Learn to program a little bit: Python plus other stuff
- Be able to post stuff to the web
- Understand a bit about computer security
- Be able to identify when it’s right to make the machine work versus doing it by hand
- Discuss the way computers have changed how we do things and the new problems they have created
Prerequisites

- Coursework: None
- Language: Can read/write/speak English
- Math: can do arithmetic, understand formulas less complex than trajectory calculations (!)
- Have access to a computer, can install software on it
Mechanics of Lecture

- Discuss Aspects of Computing
- Work on problems together, hand some in for credit
- Demonstrate programs and programming
- Various activities associated with computing
How to Think Like a Computer Scientist: Learning with Python 3

by Peter Wentworth, Jeffrey Elkner, Allen B. Downey, and Chris Meyers

Available for free online.
We’re on the Web

Piazza: Most course business
Should all have received an invitation to join the Piazza class (piazza.com)

▶ HW Questions
▶ Review questions
▶ Announcements
▶ Schedule

Blackboard only for

▶ Assignment submission
▶ Grades

Mail me for

▶ Personal appointments
▶ Unresolvable grading disputes
## Coursework

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Next Time

- Read *Pattern* Chapters 0 and 1
- Start playing with code.org
- HW 1 is posted, due next week