1 Introduction: Computers

Welcome!

CMSC 240 - Principles of Computer Organization
Class website: https://cs.brynmawr.edu/Courses/cs240/Spring2021/

What is a computer?

A device with

- A processor (CPU - Central Processing Unit)
- Storage/memory (RAM, Disk, USB Stick)
- A keyboard
- A mouse
- A monitor
- A printer

Not all computers have all of the above. **Except the CPU and memory.**

Japan's Fugaku Supercomputer is one of the world's fastest computer as of Summer 2020. Performance is over 400 petaflops (over a million times faster than the desktop shown on the right).

**Question:** What was the first ever computer?
ENIAC
Electronic Numerical Integrator and Computer
February 15, 1946.

Question: What is the difference between the ENIAC, the Apple Mac, the Iphone, and the Fugaku???
1937: Alan M. Turing

**Turing Machine**
[A mathematical abstraction of mechanical computation.]

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**Turing Machines for adding and multiplying**

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**Universal Turing Machine**

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**Church-Turing Thesis (tl;dr)**
Anything that can be computed can be computed by a Turing machine.

**Key Idea:**
A computer is essentially a Turing Machine. A computer is a universal computing device.
1 "THE BEST BRITISH FILM OF THE YEAR"

"THE IMITATION GAME"

BENEDICT CUMBERBATCH
KEIRA KNIGHTLEY

BASED ON THE INCREDBILE TRUE STORY OF ALAN TURING

STUDIOCANAL
John von Neumann, 1945

Stored Program Computers

Aka von Neumann Architecture

Most computers today are based on this architecture.
PROBLEM

Compute the square root of a given number, \( a \).

A SOLUTION

To compute the square root \( x = \sqrt{a} \) do the following:

1. Start with some guess \( x_1 > 0 \)
2. Compute a sequence of guesses \( x_1, x_2, \ldots, x_n \) using the equation:

\[
x_{n+1} = \frac{1}{2} \left( x_n + \frac{a}{x_n} \right)
\]

until the numbers produced converge.

ALGORITHM

1. To compute \( \sqrt{a} \).
2. Start with \( x_i = 1 \). This is our initial guess (See Exercises).
3. Compute the next guess: \( x_{i+1} = \frac{1}{2} \left( x_i + \frac{a}{x_i} \right) \)
4. If \( x_{i+1} \neq x_i \)
   set \( x_i \) to be same as \( x_{i+1} \).
   and then repeat from Step 3.
Otherwise because \( x_{i+1} = x_i \), they have converged. Therefore, \( \sqrt{a} = x_{i+1} \).

Computer scientists will recognize the above as an algorithm for computing \( \sqrt{a} \). It is precise, unambiguous, and effective. An algorithm is effective if its steps can be followed to produce an answer.

PROGRAM

```c
double sqrt (double a) {
    if (a <= 0) return 0;

    double x0 = 1;                  // Start with \( x_i = 1 \)
    double x1 = (x0 + a / x0) / 2;  // Compute the next guess

    while (x0 != x1) {
        x0 = x1;
        x1 = (x1 + (a / x1)) / 2;
    }
    return x1;
} // sqrt()
```
double sqrt (double a) {
    if (a <= 0) return 0;  

    double x0 = 1;  // Start with x₀ = 1
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    }
    return x1;
} // sqrt()
Levels of Transformation

1. Introduction: Programs to Electrons
2. Algorithms
3. Language
4. Machine (ISA) Architecture
5. Microarchitecture
6. Circuits
7. Devices

LC-3

Java code

Machine code

\( \sqrt{a} \)