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### From Theory to Practice: C/C++ Solutions for Real-Life Science and Engineering Challenges Tassadaq Hussain Professor Namal University

Collaborations: Microsoft Research and Barcelona Supercomputing Center Barcelona, Spain European Network on High Performance and Embedded Architecture and Compilation UCERD Gathering Intellectuals

### From the Age of Computing to the Age of Data

- Real world Problems
- Data Science
  - Technologies
  - Skills
  - Organizational Changes
  - Compliance And Ethics
- Coding Languages
  - Programming Languages
  - Scripting Languages





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Data

Centric

Problem

UJEIGOID

Ces .

### Most in-demand programming languages of 2022

Based on LinkedIn job postings in the USA & Europe



### Size of programming language communities in Q3 2021

Active software developers, globally, in millions (n=12,506)



(\*) JavaScript includes CoffeeScript and TypeScript



## **Problem Program and Process**









### **Data Processing**



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# Signal Processing System





Peripheral and I/O devices

https://www.circuitbasics.com/types-of-memory-on-the-arduino/





# Why C/C++

#### 1. Object-Oriented

C++ is an object-oriented programming language which means that the main focus is on objects and manipulations around these objects. This makes it much easier to manipulate code, unlike procedural or structured programming which requires a series of computational steps to be carried out.

#### 2. Speed

When speed is a critical metric, C++ is the most preferred choice. The compilation and execution time of a C++ program is much faster than most real-time and general-purpose programming languages.

#### 3. Compiled

Unlike other programming languages where no compilation is required, every C++ code has to be first compiled to a low-level language and then executed.

#### 4. Rich Library Support

The C++ Standard Template Library (STL) has many functions available to help write code quickly. For example, there are STLs for various containers like hash tables, maps, sets, etc.

#### 5. Pointer Support

C++ also supports pointers which are often not available in other programming languages.

#### 6. Closer to Hardware

C++ is closer to hardware than most general-purpose programming languages. This makes it very useful in those areas where hardware and software are closely coupled together, and low-level support is needed at the software level.

#### 7. Vast range of targeted technologies

- 8. Large Community
- 9. Big-Projects (Operating System)

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# Advanced C/C++ Programmings

- C/C++
- Parallel
  - Pthread Libraries
- Parallel Programming Models
  - OpenMP
  - MPI

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- OpenACC
- OpenCL



## **Processing Applications**

- Sound applications
  - Compression, enhancement, special effects, synthesis, recognition, echo cancellation,...
  - Cell Phones, MP3 Players, Movies, Dictation, Text-to-speech,...
- Communication
  - Modulation, coding, detection, equalization, echo cancellation,...
  - Cell Phones, dial-up modem, DSL modem, Satellite Receiver,...
- Automotive
  - ABS, GPS, Active Noise Cancellation, Cruise Control, Parking,...
- Medical
  - Magnetic Resonance, Tomography, Electrocardiogram,...
- Military
  - Radar, Sonar, Space photographs, remote sensing,...
- Image and Video Applications
  - DVD, JPEG, Movie special effects, video conferencing,...
- Mechanical
  - Motor control, process control, oil and mineral prospecting,...



### Levels of processing

### **Scalar Processing**

### $\blacktriangleright$ Perform single operation on a single signal value

### **Stream Processing**

 All computations with one input sample are completed before the next input sample arrives

### **Block processing**

 Each input sample x(n) is stored in memory before any processing occurs upon it. After L input samples have arrived, the entire collection of samples is processed at once.

### **Vector processing**

 Systems with several input and/or output signals being computed at once: can work with streams or blocks UCERD



# **Programming Application**

- Data Input Output
- Data Types
- Conditional Statements
- Repetition Statements
- Functions and Libraries





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- Data Input Output
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Sensor, stored, etc. Local Database, Dataset

System



- Data Input Output
- Data Types
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- Repetition Statements
- Functions and Libraries



System



- Data Input Output
- Data Types
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## Environment

- # Libraries
- # Read data
- # Operations: Filtering, Processing, Classification, Control etc.
- # Visualizing

### # Write, Operate etc



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## **Libraries and Functions**

https://www.programiz.com/c-programming/online-compiler/

#include <stdio.h>
#include "maths.h"



## Data Types/Structure

Scalar: int a, b,c; float x,y,z;

Vector

Arrays: int ab[1000]

Pointers





if (condition\_true)

e.g. if (gpa > 2) print gpa



## Repetition

for (int x=0; x<100; x=x+1)</pre>





# Write functions which solve tasks (math, signal processing, etc) efficiently.

**1**.Make a function that takes two integer inputs and applies Binary XOR and return the value.

2.Write a function that take an address and a 32 bit values and writes 32 bit data on given address.



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Create classes in C++ that solve complex tasks by organizing data and functions into a cohesive unit.

Provide user-defined types that can encapsulate data and related operations.



## Domains

Cyber Security Game Development Embedded System Signal Processing Operating System



## **Data and Signals**



0,1,2,2.2,3,3,2.9,2,1,-.5,-2 - ------

x[10000]=0,1,2,2.2,3,3,2.9,2,1,-.5,-2]

