# Einfuehrung in Robotik und das Zusammenspiel von Software, Elektronik und Mechanik

2 SemWstd. Sommersemester 2021

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*dɪ:'ʌngewʌndtə*

**C/C++**

```
// Start of your program

int main ()
{
    return 0;
}
```

---

```
// Arduino default code

void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

---

```
// Why does Arduino not need the main?

#include <Arduino.h>

int main(void)
{
    init();

    setup();

    for (;;)
    {
        loop();
    }

    return 0;
}
```

# C++ keywords

This is a list of reserved keywords in C++. Since they are used by the language, these keywords are not available for re-definition or overloading.

| A - C | D - P | R - Z |
|---|---|---|
| alignas (since C++11) | decltype (since C++11) | reflexpr (reflection TS) |
| alignof (since C++11) | default (1) | register (2) |
| and | delete (1) | reinterpret_cast |
| and_eq | do | requires (since C++20) |
| asm | double | return |
| atomic_cancel (TM TS) | dynamic_cast | short |
| atomic_commit (TM TS) | else | signed |
| atomic_noexcept (TM TS) | enum | sizeof (1) |
| auto (1) | explicit | static |
| bitand | export (1) (3) | static_assert (since C++11) |
| bitor | extern (1) | static_cast |
| bool | false | struct (1) |
| break | float | switch |
| case | for | synchronized (TM TS) |
| catch | friend | template |
| char | goto | this |
| char8_t (since C++20) | if | thread_local (since C++11) |
| char16_t (since C++11) | inline (1) | throw |
| char32_t (since C++11) | int | true |
| class (1) | long | try |
| compl | mutable (1) | typedef |
| concept (since C++20) | namespace | typeid |
| const | new | typename |
| consteval (since C++20) | noexcept (since C++11) | union |
| constexpr (since C++11) | not | unsigned |
| constinit (since C++20) | not_eq | using (1) |
| const_cast | nullptr (since C++11) | virtual |
| continue | operator | void |
| co_await (since C++20) | or | volatile |
| co_return (since C++20) | or_eq | wchar_t |
| co_yield (since C++20) | private | while |
| | protected | xor |
| | public | xor_eq |

- (1) — meaning changed or new meaning added in C++11.
- (2) — meaning changed in C++17.
- (3) — meaning changed in C++20.

Note that `and`, `bitor`, `or`, `xor`, `compl`, `bitand`, `and_eq`, `or_eq`, `xor_eq`, `not`, and `not_eq` (along with the digraphs `<%`, `%>`, `<:`, `:>`, `%:`, and `%:%:`) provide an alternative way to represent standard tokens.

In addition to keywords, there are *identifiers with special meaning*, which may be used as names of objects or functions, but have special meaning in certain contexts: `final` (C++11), `override` (C++11), `transaction_safe` (TM TS), `transaction_safe_dynamic` (TM TS), `import` (C++20), `module` (C++20)

# Evolution of C++ Standarts

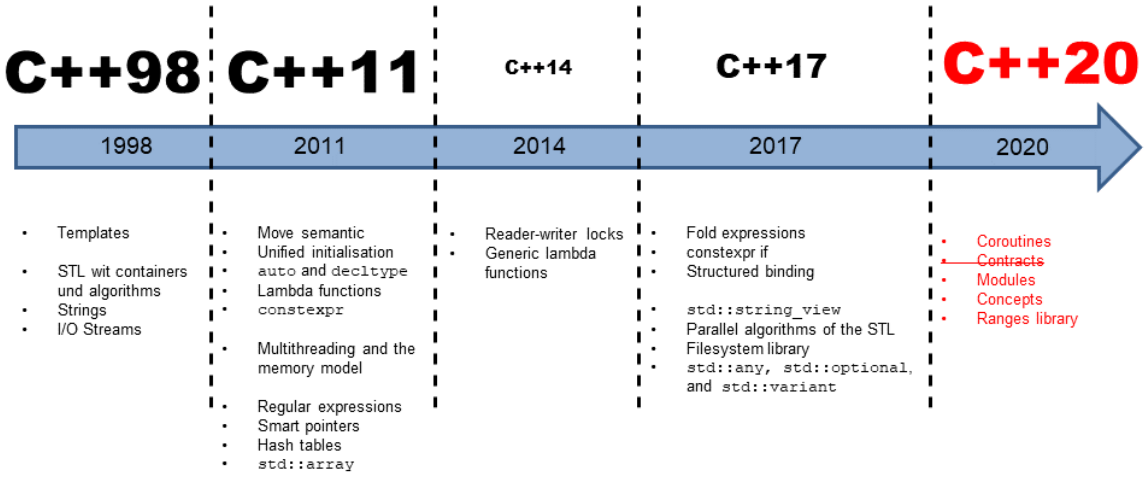



Image from: https://www.modernescpp.com/index.php/c-20-an-overview

# Family Tree of Programming Languages

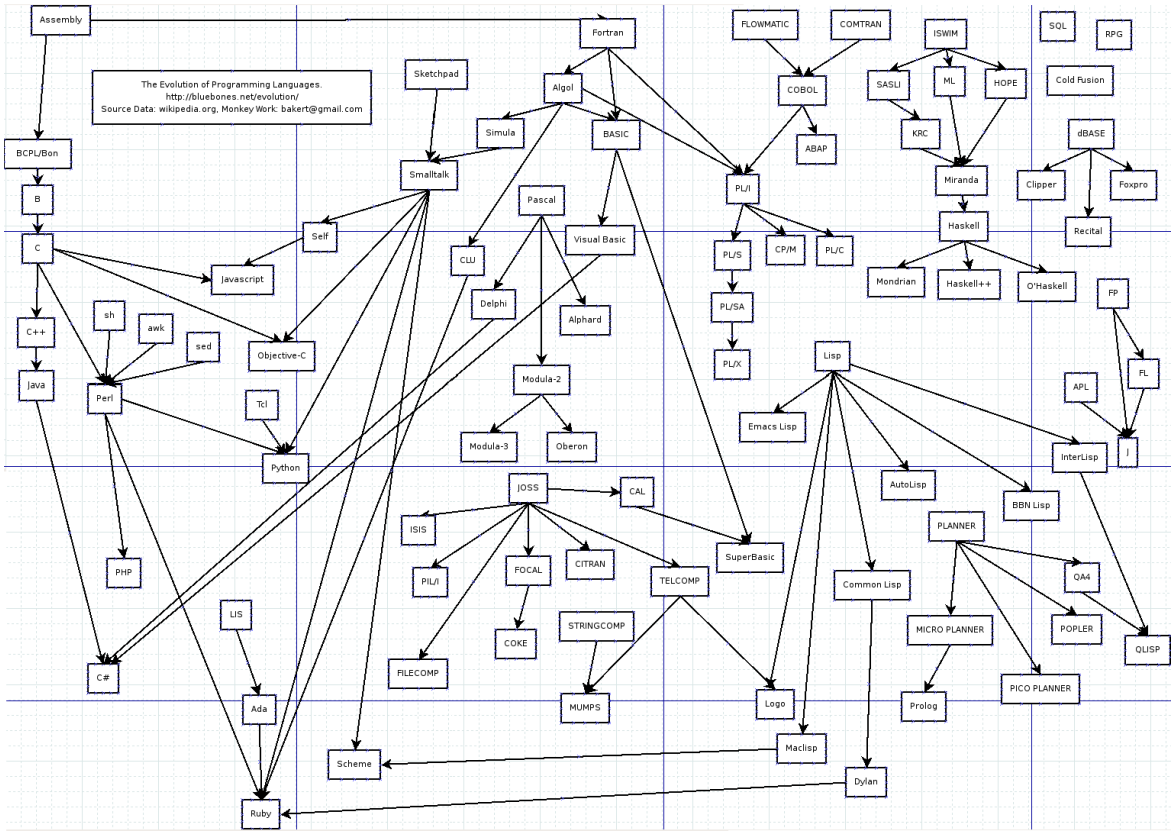
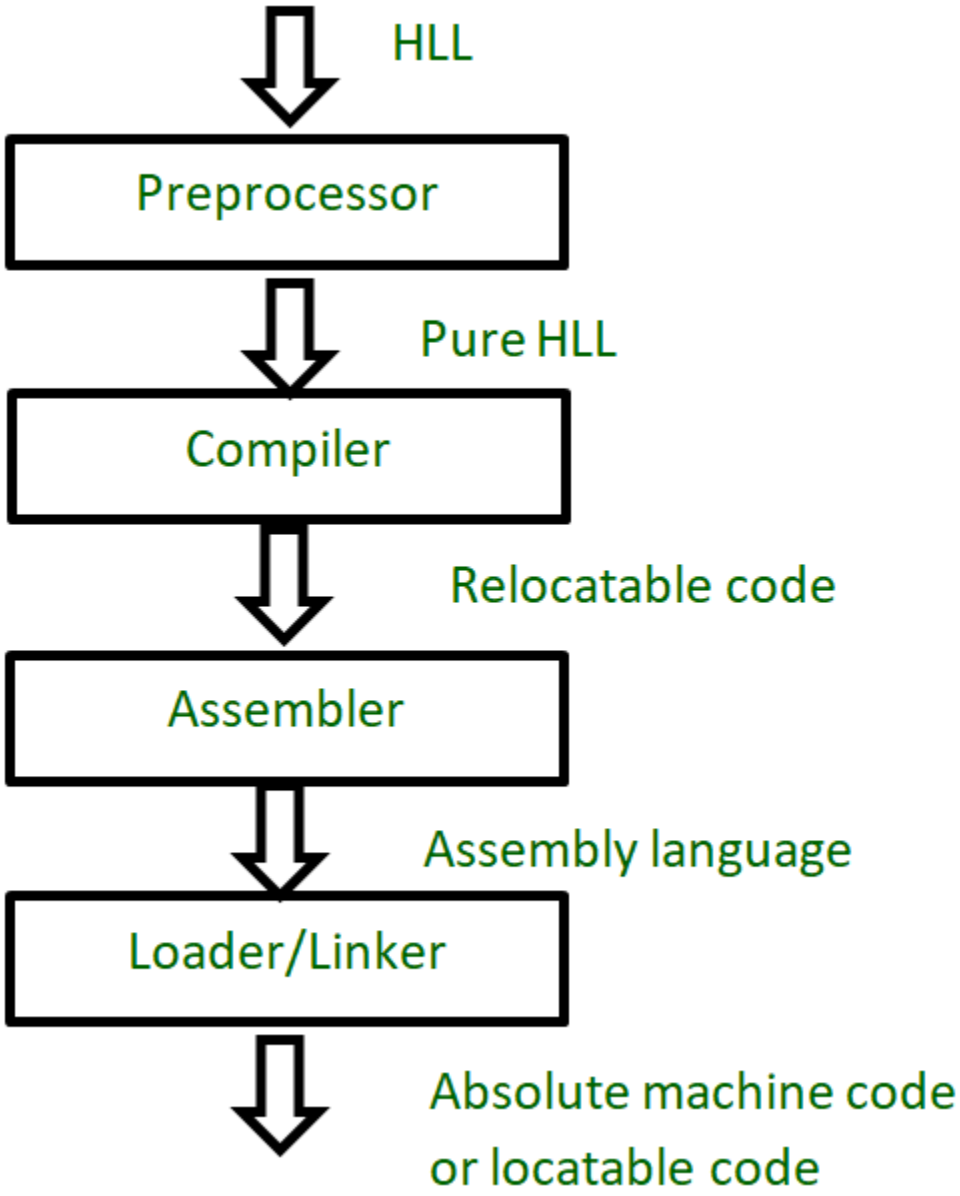



Image from: http://knowtechstuff.blogspot.com/2012/02/evolution-of-c-programming-language.html

**Compiler Tool-Chain**



## Back to Coding: (https://godbolt.org/)

## #includes

```cpp
#include <iostream> // <standard_directory> includes search
#include "iostream" // “relative” includes search

int main()
{
    // blabla bla
    // Uses Comments to explain what you are doing
    // Try avoiding leaving deactivated code as comments
    /*
       More form of comments
       std::cout got included from the iostream library
    */

    std::cout << "Hello World" << std::endl;

    return 0;
}
```

---

# Header Files *.h and Source Files *.cpp

C++ Separate Header and Implementation FilesC++ classes (and often function prototypes) are normally split up into two files. The header file has the extension of .h and contains class definitions and functions. The implementation of the class goes into the .cpp file. By doing this, if your class implementation doesn't change then it won't need to be recompiled. Most IDE's will do this for you – they will only recompile the classes that have changed. This is possible when they are split up this way, but it isn't possible if everything is in one file (or if the implementation is all part of the header file).

```
//File: Num.h
class Num
{
  private:
    int num;
  public:
    Num(int n);
    int getNum();
};
```

```
//File: Num.cpp
#include "Num.h"

Num::Num() : num(0) { }

Num::Num(int n) : num(n) {}

int Num::getNum()
{
  return num;
}
```

```
//File: main.cpp
#include <iostream>
#include "Num.h"

using namespace std;

int main()
{
  Num n(35);
  cout << n.getNum() << endl;
  return 0;
}
```

## #defines and Pre-Compiler statements

```
#include <iostream>

#define DANIEL

int main()
{

#ifdef DANIEL
    std::cout << "Hallo Daniel" << std::endl;
#else
    std::cout << "Hallo not Daniel" << std::endl;
#endif

}
```

```
#include <iostream>

#define MY_TEXT   "Hallo this is my Text"

int main()
{
    std::cout << MY_TEXT << std::endl;
}
```

## #define Macros

```
#include <iostream>

#define abs(x)  (x < 0 ? -x : x)

int main()
{
    std::cout << abs(-10) << std::endl;
}
```

# Variables

**Int Integer (Ganzezahlen) …-1,0,1,2,3…255…**

**signed und unsigned int**

**Float Gleitkommazahlen 3.14159**

**Bool Booleanzahle … true (1), false (0)**

**Char/Byte (0-255 bzw 0x00-0xFF)**

**Selbstdefinierte Variablen**

**zB: typedefs, structs und class/objects**

**Variablen koennen Einzeln oder als Felder/Arrays[] definiert werden**

---

```cpp
#include <iostream>

int myGlobalVariable = 155;

int main()
{
    int myLocalVariable = 1980;

    std::cout << myGlobalVariable << std::endl;
    std::cout << myLocalVariable << std::endl;
}
```

---

# Arrays []

---

```cpp
int main()
{

    int myIntArray[10] = {0,1,2,3,4,5,6,7,8,9};

    myIntArray[0] = myIntArray[2] + myIntArray[5];

    return myIntArray[0];

}
```

# Operators

- **Assignment operator (=)**
- **Arithmetic operators ( +, -, *, /, % )**
- **Compound assignment (+=, -=, *=, /=, %=, >>=, <<=, &=, ^=, |=)**
- **Relational and comparison operators ( ==, !=, >, <, >=, <= )**
- **Logical operators ( !, &&, || )**
- **Bitwise operators ( &, |, ^, ~, <<, >> )**
- **Conditional ternary operator ( ? )**

| Level | Precedence group | Operator | Description | Grouping |
|---|---|---|---|---|
| 1 | Scope | `::` | scope qualifier | Left-to-right |
| 2 | Postfix (unary) | `++ --` | postfix increment / decrement | Left-to-right |
| | | `()` | functional forms | |
| | | `[]` | subscript | |
| | | `. ->` | member access | |
| 3 | Prefix (unary) | `++ --` | prefix increment / decrement | Right-to-left |
| | | `~ !` | bitwise NOT / logical NOT | |
| | | `+ -` | unary prefix | |
| | | `& *` | reference / dereference | |
| | | `new delete` | allocation / deallocation | |
| | | `sizeof` | parameter pack | |
| | | `(type)` | C-style type-casting | |
| 4 | Pointer-to-member | `.* ->*` | access pointer | Left-to-right |
| 5 | Arithmetic: scaling | `* / %` | multiply, divide, modulo | Left-to-right |
| 6 | Arithmetic: addition | `+ -` | addition, subtraction | Left-to-right |
| 7 | Bitwise shift | `<< >>` | shift left, shift right | Left-to-right |
| 8 | Relational | `< > <= >=` | comparison operators | Left-to-right |
| 9 | Equality | `== !=` | equality / inequality | Left-to-right |
| 10 | And | `&` | bitwise AND | Left-to-right |
| 11 | Exclusive or | `^` | bitwise XOR | Left-to-right |
| 12 | Inclusive or | `\|` | bitwise OR | Left-to-right |
| 13 | Conjunction | `&&` | logical AND | Left-to-right |
| 14 | Disjunction | `\|\|` | logical OR | Left-to-right |
| 15 | Assignment-level expressions | `= *= /= %= += -= >>= <<= &= ^= \|=` | assignment / compound assignment | Right-to-left |
| | | `?:` | conditional operator | |
| 16 | Sequencing | `,` | comma separator | Left-to-right |

# If Statements

```
int a = 2;
int sensorValue = analogRead(sensorPin);
int c = a + sensorValue;

if(c > 100)
{
    Serial.print(" c ist grosser als 100: ");
}else
{
    Serial.print(" c ist kleiner oder gleich 100");
}
```

| operator | description |
|---|---|
| == | Equal to |
| != | Not equal to |
| < | Less than |
| > | Greater than |
| <= | Less than or equal to |
| >= | Greater than or equal to |

| && OPERATOR (and) | | |
|---|---|---|
| a | b | a && b |
| true | true | true |
| true | false | false |
| false | true | false |
| false | false | false |

| \|\| OPERATOR (or) | | |
|---|---|---|
| a | b | a \|\| b |
| true | true | true |
| true | false | true |
| false | true | true |
| false | false | false |

# Loops / for and while loops

---

```
int a = 0;

for(int i = 0; i < 100; i++)
{
    a = a + i;
}

Serial.print(" a ist: ");
Serial.print(a);

a = 0;

while( a < 1000)
{
    a = a + a;
}
```

---

```
#include <iostream>

using namespace std;

int main()
{
    int a = 0;

    for(int i = 0; i < 7 ;i++)
    {
        cout << a << " ";
        a = a + 1;
    }

    cout << endl; // do a line break

    while( a > 0)
    {
        a--;
        cout << a << " ";
    }

    return 1;
}
```

# Function-definition:

```cpp
#include <iostream>

int HalloDoMath(int a, int b)
{
    int myReturnValue = a + b;
    return myReturnValue;
}

int main()
{
    std::cout << HalloDoMath(12, 8);
    return 1;
}
```

---

```cpp
#include <iostream>

// forward declaration
int HalloDoMath(int a, int b);

int main()
{
    std::cout << HalloDoMath(12, 8);
    return 1;
}

int HalloDoMath(int a, int b)
{
    int myReturnValue = a + b;
    return myReturnValue;
}
```

## Pointers, the Address-Operator & and de-referencing *

```cpp
#include <iostream>

using namespace std;

int main()
{
    int a = 1505;

    cout << "Value: " << a << " Address in Memory: " << &a << endl;
}
```

---

```cpp
#include <iostream>

using namespace std;

int main()
{
    int a = 1505;
   // Output as hex value
    cout << "0x" << hex << a << " " << dec << a << endl;
}
```

---

```cpp
#include <iostream>

using namespace std;

int a = 1505;
int b = 1980;

int main()
{
    cout << a << " " << b << endl;

    cout << &a << " " << &b << endl;

    cout << &a + 1 << endl;

    cout << *(&a + 1) << endl;

}
```

# Pass by value, pointer and reference

```cpp
#include <iostream>

using namespace std;

int MyFunction(int a, int* b, int& c)
{
    a = a + 1;
    *b = *b + 1;
    c = c + 1;

    return a + *b + c;
}

int main()
{
    int a = 1;
    int b = 2;
    int c = 3;

    cout << a << " " << b << " " << c << endl;

    cout << MyFunction(a, &b, c) << endl;

    cout << a << " " << b << " " << c << endl;
}
```

# Structs and classes

```cpp
#include <iostream>

using namespace std;

struct MyStruct
{
    int a = 1;
    int b = 2;
    int c = 3;
};

int MyFunction(MyStruct myS)
{
    myS.a =  myS.a + 1;
    myS.b =  myS.b + 1;
    myS.c =  myS.c + 1;

    return  myS.a +  myS.b +  myS.c;
}

int main()
{
    MyStruct myInst;

    cout << myInst.a << " " << myInst.b << " " << myInst.c << endl;

    cout << MyFunction(myInst) << endl;

    cout << myInst.a << " " << myInst.b << " " << myInst.c << endl;

}
```

---

```cpp
class MyStruct
{
private:

public:
    int a = 1;
    int b = 2;
    int c = 3;
};
```

# Constructors and De-structors

```
#include <iostream>

using namespace std;

struct MyStruct
{
    MyStruct() // default constructor
    {
        cout << "Constructor 1 called..." << endl;
    }

    MyStruct(int A, int B, int C) // constructor with parameters
    {
        a = A; b = B; c = C;

        cout << "Constructor 2 called..." << endl;
    }

    MyStruct(const MyStruct& source) // copy constructor
    {
         cout << "Constructor 3 called..." << endl;
    }

    ~MyStruct()
    {
        cout << "Destructor called..." << endl;
    }

    int a = 1;  int b = 2;  int c = 3;
};

int MyFunction(MyStruct myS)
{
    return  myS.a +  myS.b +  myS.c;
}

int main()
{
    MyStruct myInst;

    cout << MyFunction(myInst) << endl;

}
```

# Overloaded functions

---

```
int MyFunction(MyStruct myS)
{
    return  myS.a +  myS.b +  myS.c;
}

int MyFunction(MyStruct *myS)
{
    return  myS->a +  myS->b +  myS->c;
}

int MyFunction(MyStruct &myS, int andSoOn)
{
    return  myS.a +  myS.b +  myS.c + andSoOn;
}
```

# The Keyword static

```
#include <iostream>

using namespace std;

void MyFunction1()
{

    int a = 0;

    a++;

    cout << "1: " << a << endl;

}

void MyFunction2()
{

    static int a = 0;

    a++;

    cout << "2: " << a << endl;

}


int main()
{

   for(int i = 0; i < 5; i++)
   {

       MyFunction1();

       MyFunction2();

   }

}
```

```cpp
#include <iostream>

using namespace std;

int InstanceID = 0;

struct MyStruct
{
   // static int InstanceID ;
    int Id = -1;

    MyStruct() // default constructor
    {
        Id = InstanceID;
        InstanceID++;
        cout << "Constructor 1 called of ID: " << Id << endl;
    }

    MyStruct(int A, int B, int C) // constructor with parameters
    {
        Id = InstanceID;
        InstanceID++;

        a = A;
        b = B;
        c = C;

        cout << "Constructor 2 called of ID: " << Id <<endl;
    }

    MyStruct(const MyStruct& source) // copy constructor
    {
        Id = InstanceID;
        InstanceID++;

        cout << "Constructor 3 called of ID: " << Id << endl;
    }

    ~MyStruct()
    {
        cout << "Destructor called of ID: " << Id << endl;
    }

    int a = 1;  int b = 2;   int c = 3;

    MyStruct operator+(const MyStruct& b) // overloaded opertor
```

```
    {
        MyStruct res;
        res.a = this->a + b.a;
        res.b = this->b + b.b;
        res.c = this->c + b.c;
        return res;
    }

    MyStruct operator+(const int b)  // overloaded opertor
    {
        MyStruct res;
        res.a = this->a + b;
        res.b = this->b + b;
        res.c = this->c + b;
        return res;
    }

};

int MyFunction(MyStruct myS)
{
    myS.a =  myS.a + 1;
    myS.b =  myS.b + 1;
    myS.c =  myS.c + 1;

    return  myS.a +  myS.b +  myS.c;
}

//int MyStruct::InstanceID = 0;

int main()
{
    MyStruct myInst;

    cout << MyFunction(myInst + 1) << endl;
}
```

## And more like new and delete …