

EECS 22: Advanced C Programming

Lecture 6

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Lecture 6: Overview

- Review of the C Programming Language
 - Types
 - Basic Type Ranges
 - Type Conversion
 - Types in Expressions
 - Type Qualifiers
 - Application Example `PhotoLab.c`

Basic Type Ranges

- Integer Types
 - **char** Character, e.g. `'a'`, `'b'`, `'1'`, `'*'`
 - typical range **8 bit** [-128,127]
 - **short int** Short integer, e.g. -7, 0, 42
 - typical range **16 bit** [-32768,32767]
 - **int** Integer, e.g. -7, 0, 42
 - typical range **32 bit** [-2147483648,2147483647]
 - **long int** Long integer, e.g. -99L, 9L, 123L
 - typical range **32 bit** [-2147483648,2147483647]
 - **long long int** Very long integer, e.g. 12345LL
 - typical range **64 bit** [-9223372036854775808,9223372036854775807]
- Integer Types can be
 - **signed** negative and positive values (incl. 0)
 - **unsigned** positive values only (incl. 0)

Basic Type Ranges

- Floating Point Types
 - **float** Floating point with single precision
 - Typical representation: **24 + 8 = 32 bit**
 - Example: `3.5f`, `-0.234f`, `10e8f`
 - **double** Floating point with double precision
 - Typical representation: **53 + 11 = 64 bit**
 - Example: `3.5`, `-0.23456789012`, `10e88`
 - **long double** Floating point with high precision
 - Typical representation: **113 + 15 = 128 bit**
 - Example: `12345678.123456e123L`

Type Conversion

- Explicit Type Conversion
 - types can be explicitly converted to other types, by use of the type cast operator:
 - `(type) expression`
 - the target type is named explicitly in parentheses before the source expression
 - Examples:
 - `Float = (float) LongInt`
 - converts the `long int` value into a `float` value
 - `Integer = (int) Double`
 - converts the `double` value into an `int` value
 - any fractional part is truncated!
 - `Char = (char) LongLongInt`
 - converts the `long long int` value into a `char` value
 - any out-of-range values are silently cut off!

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5

Type Conversion

- Implicit Type Conversion
 - Type promotion
 - integral promotion
 - `unsigned` or `signed char` is promoted to `unsigned` or `signed int` before any operation
 - `unsigned` or `signed short` is promoted to `unsigned` or `signed int` before any operation
 - binary arithmetic operators are defined only for same types
 - the smaller type is converted to the larger type (before operation)
 - Examples:
 - » `ShortInt * LongInt` results in a `long int` type
 - » `LongDouble * Float` results in a `long double` type
 - Type coercion
 - most types are automatically converted to expected types
 - Example: `Double = Float`, or `Char = LongInt`

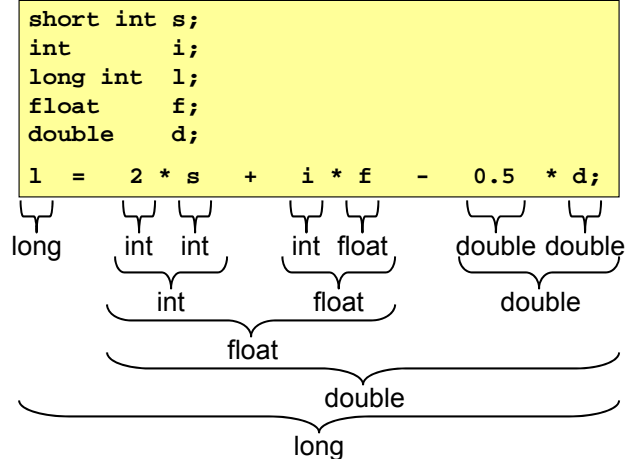
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6

Types in Expressions

- Expressions are composed of constants, variables and operators, each of which has an associated type
- Example:



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7

Type Qualifiers

- Types may be further qualified
 - Type qualifier **const**
 - The value of a **const** object cannot be changed
 - Initialization is OK, assignment is not
 - Example:
 - `const double pi = 3.1415926536;`
 - Object may be placed in read-only memory (ROM)
 - Type qualifier **volatile**
 - The value of a **volatile** object must not be used for compiler optimizations
 - Machine registers for memory-mapped I/O are volatile
 - Example:
 - `volatile char *StatusReg = 0x40000000;`
 - `while(*StatusReg == 0x00) ;`
 - Accesses to **volatile** objects must not be optimized away

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8

Application Example

- Program example: **PhotoLab**
 - Digital image manipulation
 - Read an image from a file
 - Manipulate the image in memory
 - Write the modified image to file
 - Portable Pixel Map (PPM) file format
 - simple uncompressed file format for color images
 - Header section (including picture width, height)
 - Data section (pixel values in Red/Green/Blue format)

```
P6
640 480
255
RGBRGBRGB...
```

Application Example

- Program example: **PhotoLab.c** (part 1/5)

```

/*****
/* PhotoLab.c: assignment 2 for EECS 22 in Fall 2016 */
/*
/* modifications: (most recent first) */
/* 10/05/16 RD adjusted for lecture usage */
*****/

#include <stdio.h>
#include <stdlib.h>

/** global definitions **/

const int WIDTH = 640; /* image width */
const int HEIGHT = 480; /* image height */
const int SLEN = 80; /* max. string length */

...

```

Application Example

- Program example: PhotoLab.c (part 2/5)

```
...
/** function definitions */

/* write the RGB image to a PPM file */
/* (return 0 for success, >0 for error) */

int SaveImage(const char Filename[SLEN],
              unsigned char R[WIDTH][HEIGHT],
              unsigned char G[WIDTH][HEIGHT],
              unsigned char B[WIDTH][HEIGHT])
{
    ...
} /* end of SaveImage */
...
```

Application Example

- Program example: PhotoLab.c (part 3/5)

```
...

/* read an image file into the RGB data structure */
/* (return 0 for success, >0 for error) */

int ReadImage(const char fname[SLEN],
              unsigned char R[WIDTH][HEIGHT],
              unsigned char G[WIDTH][HEIGHT],
              unsigned char B[WIDTH][HEIGHT])
{
    ...
} /* end of ReadImage */
...
```

Application Example

- Program example: PhotoLab.c (part 4/5)

```

...
/* modify the image... ;-) */

void ModifyImage(unsigned char R[WIDTH][HEIGHT],
                unsigned char G[WIDTH][HEIGHT],
                unsigned char B[WIDTH][HEIGHT])
{
    int x, y;

    for(y=0; y<HEIGHT; y++)
    {
        for(x=0; x<WIDTH; x++)
        {
            B[x][y] = (R[x][y] + G[x][y] + B[x][y]) / 5;
            R[x][y] = (unsigned char) (B[x][y]*1.6);
            G[x][y] = (unsigned char) (B[x][y]*1.6);
        }
    }
}

} /* end of ModifyImage */
...

```

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13

Application Example

- Program example: PhotoLab.c (part 5/5)

```

...
/** main program */

int main(void)
{
    unsigned char R[WIDTH][HEIGHT];
    unsigned char G[WIDTH][HEIGHT];
    unsigned char B[WIDTH][HEIGHT];

    if (ReadImage("EH.ppm", R,G,B) != 0)
    { return 10; }
    ModifyImage(R, G, B);
    if (SaveImage("EH1965.ppm", R,G,B) != 0)
    { return 10; }
    return 0;
} /* end of main */

/* EOF */

```

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14

Application Example

- Example session: PhotoLab.c

```
% vi PhotoLab.c
% gcc PhotoLab.c -o PhotoLab -Wall -ansi
% pnmtjpeg EH.ppm > EH.jpg
% PhotoLab
% pnmtjpeg EH1965.ppm > EH1965.jpg
%
```

EH.ppm



EH1965.ppm

