Lecture 7.2: Overview

- Passing arguments to functions
  - Pass by value
  - Pass by reference
- Character Arrays: Strings
  - Input and output
  - ASCII table
  - Example: Sort strings alphabetically
    - Task
    - Approach
    - Algorithm *Bubble Sort*
    - Program **`BubbleSort.c`**

Passing Arguments to Functions

- Pass by Value
  - only the *current value* is passed as argument
  - the parameter is a *copy* of the argument
  - changes to the parameter *do not* affect the argument
- Pass by Reference
  - a *reference* to the object is passed as argument
  - the parameter is a *reference* to the argument
  - changes to the parameter *do* affect the argument
- In ANSI C, ...
  - ... basic types are passed by value
  - ... arrays are passed by reference

Passing Arguments to Functions

- Example: Pass by Value

```
void f(int p)
{
   printf("p before modification is  %d\n", p);
   p = 42;
   printf("p after modification is   %d\n", p);
}

int main(void)
{
   int a = 0;

   printf("a before function call is %d\n", a);
   f(a);
   printf("a after function call is  %d\n", a);
}
```

```
a before function call is 0
p before modification is  0
p after modification is   42
a after function call is  0
```

Changes to the parameter *do not* affect the argument!

Passing Arguments to Functions

- Example: Pass by Reference

```
void f(int p[2])
{
   printf("p[1] before modification is  %d\n", p[1]);
   p[1] = 42;
   printf("p[1] after modification is   %d\n", p[1]);
}

int main(void)
{
   int a[2] = {0, 0};

   printf("a[1] before function call is %d\n", a[1]);
   f(a);
   printf("a[1] after function call is  %d\n", a[1]);
}
```

```
a[1] before function call is 0
p[1] before modification is  0
p[1] after modification is   42
a[1] after function call is  42
```

Changes to the parameter *do* affect the argument!

Character Arrays: Strings

- Text is represented by character arrays (aka. *strings*)
  - Strings are null-terminated arrays of characters
  - String output
    - **`printf()`** format specifier: **`"%s"`**
- Example:

```
char s1[] = {'H','e','l','l','o',0};

printf("s1 is %s.\n", s1);
```

```
s1 is Hello.
```

	s1
0	'H'
1	'e'
2	'l'
3	'l'
4	'o'
5	0

Character Arrays: Strings

- Text is represented by character arrays (aka. *strings*)
  - Strings are null-terminated arrays of characters
  - String output
    - **`printf()`** format specifier: **`"%s"`**
- Example:

```
char s1[] = {'H','e','l','l','o',0};
char s2[] = "Hello";

printf("s1 is %s.\n", s1);
printf("s2 is %s.\n", s2);
```

```
s1 is Hello.
s2 is Hello.
```

	s2
0	'H'
1	'e'
2	'l'
3	'l'
4	'o'
5	0

Character Arrays: Strings

- Text is represented by character arrays (aka. *strings*)
  - Strings are null-terminated arrays of characters
  - String output
    - **`printf()`** format specifier: **`"%s"`**
- Example:

```
char s1[] = {'H','e','l','l','o',0};
char s2[] = "Hello";

printf("s1 is %s.\n", s1);
printf("s2 is %s.\n", s2);
s1[1] = 'i';
s1[2] = 0;
printf("Modified s1 is %s.\n", s1);
```

```
s1 is Hello.
s2 is Hello.
Modified s1 is Hi.
```

	s1
0	'H'
1	'i'
2	0
3	'l'
4	'o'
5	0

Character Arrays: Strings

- Text is represented by character arrays (aka. *strings*)
  - Strings are null-terminated arrays of characters
  - String input
    - **`scanf()`** format specifier: **`"%Ns"`**,
      where **`N`** specifies maximum field width = array size - 1
    - address argument can be **`&string[0]`**
- Example:

```
char s1[6];

printf("Enter a string: ");
scanf("%5s", &s1[0]);
printf("s1 is %s.\n", s1);
```

```
Enter a string: Test
s1 is Test.
```

	s1
0	'T'
1	'e'
2	's'
3	't'
4	0
5	0

Character Arrays: Strings

- Text is represented by character arrays (aka. *strings*)
  - Strings are null-terminated arrays of characters
  - String input
    - **`scanf()`** format specifier: **`"%Ns"`**, where **`N`** specifies maximum field width = array size - 1
    - address argument can be ***`&string`*`[0]`** or simply ***`string`***
- Example:

```
char s1[6];

printf("Enter a string: ");
scanf("%5s", s1);
printf("s1 is %s.\n", s1);
```

```
Enter a string: Test
s1 is Test.
```

	s1
0	'T'
1	'e'
2	's'
3	't'
4	0
5	0

Character Arrays: Strings

- Text is represented by character arrays (aka. *strings*)
  - Strings are null-terminated arrays of characters
  - Characters are represented by numeric values
  - ASCII table defines character values 0-127
- Example:

```
char s1[] = "ABC12";
int i = 0;

while(s1[i])
  { printf("%c = %d\n",s1[i],s1[i]);
    i++; }
```

```
A = 65
B = 66
C = 67
1 = 49
2 = 50
```

	s1
0	'A'
1	'B'
2	'C'
3	'1'
4	'2'
5	0

Character Arrays: Strings

- ASCII Table
  - American Standard Code for Information Interchange

0 *NUL*	1 *SOH*	2 *STX*	3 *ETX*	4 *EOT*	5 *ENQ*	6 *ACK*	7 *BEL*
8 *BS*	9 *HT*	10 *NL*	11 *VT*	12 *NP*	13 *CR*	14 *SO*	15 *SI*
16 *DLE*	17 *DC1*	18 *DC2*	19 *DC3*	20 *DC4*	21 *NAK*	22 *SYN*	23 *ETB*
24 *CAN*	25 *EM*	26 *SUB*	27 *ESC*	28 *FS*	29 *GS*	30 *RS*	31 *US*
32	33 !	34 "	35 #	36 $	37 %	38 &	39 '
40 (	41)	42 *	43 +	44 ,	45 -	46 .	47 /
48 0	49 1	50 2	51 3	52 4	53 5	54 6	55 7
56 8	57 9	58 :	59 ;	60 <	61 =	62 >	63 ?
64 @	65 A	66 B	67 C	68 D	69 E	70 F	71 G
72 H	73 I	74 J	75 K	76 L	77 M	78 N	79 O
80 P	81 Q	82 R	83 S	84 T	85 U	86 V	87 W
88 X	89 Y	90 Z	91 [	92 \	93]	94 ^	95 _
96 `	97 a	98 b	99 c	100 d	101 e	102 f	103 g
104 h	105 i	106 j	107 k	108 l	109 m	110 n	111 o
112 p	113 q	114 r	115 s	116 t	117 u	118 v	119 w
120 x	121 y	122 z	123 {	124 |	125 }	126 ~	127 *DEL*

Character Arrays: Strings

- Case Study: *Bubble Sort*
  - Task: Sort an array of strings alphabetically
  - Input: Array of 10 strings entered by the user
  - Output: Array of 10 strings in alphabetical order
- Approach: Divide and Conquer
  - Step 1: Let user enter 10 strings
  - Step 2: Sort the array of strings
  - Step 3: Output the strings in order

Character Arrays: Strings

- Case Study: *Bubble Sort*
  - Task: Sort an array of strings alphabetically
  - Input: Array of 10 strings entered by the user
  - Output: Array of 10 strings in alphabetical order
- Approach: Divide and Conquer
  - Step 1: Let user enter 10 strings
  - Step 2: Sort the array of strings
    - Algorithm
      - in 9 rounds, compare all adjacent pairs of strings and swap the pair if they are not in alphabetical order
    - String comparison
      - compare character pairs alphabetically: use ASCII values!
    - String swap (exchange two strings in place)
      - swap each character pair in the two strings
  - Step 3: Output the strings in order

Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 1/7)

```
/* BubbleSort.c: sort strings alphabetically    */
/* author: Rainer Doemer                        */
/* modifications:                               */
/* 11/01/06 RD  swap only adjacent elements     */
/* 11/06/04 RD  initial version                 */

#include <stdio.h>

/* constant definitions */

#define NUM 10  /* ten strings  */
#define LEN 20  /* of length 20 */

/* function declarations */

void EnterText(char Text[NUM][LEN]);
void PrintText(char Text[NUM][LEN]);
int CompareStrings(char s1[LEN], char s2[LEN]);
void SwapStrings(char s1[LEN], char s2[LEN]);
void BubbleSort(char Text[NUM][LEN]);
...
```

Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 2/7)

```
...

/* function definitions */

/* let the user enter the text array            */

void EnterText(char Text[NUM][LEN])
{
   int i;

   for(i = 0; i < NUM; i++)
      { printf("Enter text string %2d: ", i+1);
        scanf("%19s", Text[i]);
       } /* rof */
} /* end of EnterText */

...
```


Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 3/7)

```
...

/* print the text array on the screen           */

void PrintText(char Text[NUM][LEN])
{
   int i;

   for(i = 0; i < NUM; i++)
      { printf("String %2d: %s\n", i+1, Text[i]);
       } /* rof */
} /* end of PrintText */

...
```

Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 4/7)

```
...
/* alphabetically compare strings s1 and s2:    */
/* return -1, if string s1 < string s2          */
/* return  0, if string s1 = string s2          */
/* return  1, if string s1 > string s2          */

int CompareStrings(char s1[LEN], char s2[LEN])
{
   int i;

   for(i = 0; i < LEN; i++)
      { if (s1[i] > s2[i])
           { return(1); }
        if (s1[i] < s2[i])
           { return(-1); }
        if (s1[i] == 0 || s2[i] == 0)
           { break; }
       } /* rof */
   return 0;
} /* end of CompareStrings */
...
```


Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 5/7)

```
...

/* swap/exchange the strings s1 and s2 in place */

void SwapStrings(char s1[LEN], char s2[LEN])
{
   int  i;
   char c;

   for(i = 0; i < LEN; i++)
      { c = s1[i];
        s1[i] = s2[i];
        s2[i] = c;
       } /* rof */
} /* end of SwapStrings */

...
```

Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 6/7)

```
...
/* sort the text array by comparing every pair  */
/* of strings; if the pair of strings is not in */
/* alphabetical order, swap it                  */

void BubbleSort(char Text[NUM][LEN])
{
   int p, i;

   for(p = 1; p < NUM; p++)
      { for(i = 0; i < NUM-1; i++)
           { if (CompareStrings(Text[i], Text[i+1]) > 0)
                { SwapStrings(Text[i], Text[i+1]);
                 } /* fi */
            } /* rof */
       } /* rof */
} /* end of BubbleSort */

...
```


Character Arrays: Strings

- Program example: **`BubbleSort.c`** (part 7/7)

```
...
/* main function: enter, sort, print the text   */

int main(void)
{
   /* local variables */
   char Text[NUM][LEN]; /* NUM strings, length LEN */

   /* input section */
   EnterText(Text);

   /* computation section */
   BubbleSort(Text);

   /* output section */
   PrintText(Text);

   /* exit */
   return 0;
} /* end of main */

/* EOF */
```

Character Arrays: Strings

- Example session: **`BubbleSort.c`**

```
% vi BubbleSort.c
% gcc BubbleSort.c -o BubbleSort -Wall -ansi
% BubbleSort
Enter text string  1: Charlie
Enter text string  2: William
Enter text string  3: Donald
Enter text string  4: John
Enter text string  5: Jane
Enter text string  6: Jessie
Enter text string  7: Donald
Enter text string  8: Henry
Enter text string  9: George
Enter text string 10: Emily
String  1: Charlie
String  2: Donald
String  3: Donald
String  4: Emily
String  5: George
String  6: Henry
String  7: Jane
String  8: Jessie
String  9: John
String 10: William
%
```