

EECS 10: Computational Methods in Electrical and Computer Engineering

Lecture 17

Rainer Dömer

doemer@uci.edu

The Henry Samueli School of Engineering
Electrical Engineering and Computer Science
University of California, Irvine

Lecture 17: Overview

- Data Structures
 - Introduction
 - Arrays
 - Introduction
 - Indexing
 - Initialization
 - Multi-dimensional arrays
 - Operator associativity and precedence
 - Example
 - `Histogram.c`

Data Structures

- Introduction
 - Until now, we have used (mostly) single data elements of basic (non-composite) type
 - integral types
 - floating point types
 - Most programs, however, require complex *data structures* using composite types
 - arrays, lists, queues, stacks
 - trees, graphs
 - dictionaries
 - ANSI C provides built-in support for
 - arrays
 - structures, unions, enumerators
 - pointers

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Arrays

- Array data type in C
 - Composite data type
 - Type is an array of a sub-type (e.g. array of `int`)
 - Fixed number of elements
 - Array size is fixed at time of definition (e.g. 100 elements)
 - Element access by index (aka. subscript)
 - Element-access operator: `array[index]` (e.g. `A[42]`)
- Example:

```
int A[10]; /* array of ten integers */  
  
A[0] = 42; /* access to elements */  
A[1] = 100;  
A[2] = A[0] + 5 * A[1];
```

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Arrays

- Array Indexing
 - Start counting from 0
 - First element has index 0
 - Last element has index *Size-1*
- Example:

```
int A[10];

A[0] = 42;
A[1] = 100;
A[2] = A[0] + 5 * A[1];
A[3] = -1;
A[4] = 44;
A[5] = 55;
/* ... */
A[9] = 99;
```

	A
0	42
1	100
2	542
3	-1
4	44
5	55
6	0
7	0
8	0
9	99

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Arrays

- Array Indexing
 - for loops are often very helpful
 - `for(i=0; i<N; i++)`
`{...A[i]...}`
- Example:

```
int A[10];
int i;

for(i=0; i<10; i++)
{ A[i] = i*10 + i;
}

for(i=0; i<10; i++)
{ printf("%d, ", A[i]);
}
```

	A
0	0
1	11
2	22
3	33
4	44
5	55
6	66
7	77
8	88
9	99

```
0, 11, 22, 33, 44, 55, 66, 77, 88, 99,
```

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Arrays

- Array Indexing
 - Array indices are *not* checked by the compiler!
 - Accessing an array with an *index out of range* results in undefined behavior!

- Example:

```
int A[10];
int i;

A[-1] = 42; /* INVALID ACCESS! */

for(i=0; i<=10; i++)
  /* INVALID LOOP RANGE! */
  { printf("%d, ", A[i]);
  }
```

0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

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Arrays

- Array Initialization
 - Static initialization at time of array definition
 - Initial elements listed in { }

- Example:

```
int A[10] = { 42, 100,
             310, 44,
             55, 0,
             3, 4,
             0, 99};
```

	A
0	42
1	100
2	310
3	44
4	55
5	0
6	3
7	4
8	0
9	99

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Arrays

- Array Initialization
 - Static initialization at time of array definition
 - Initial elements listed in { }

- Example:

```
int A[ ] = { 42, 100,
            310, 44,
            55, 0,
            3, 4,
            0, 99};
```

- With given initializer list, array size may be omitted
 - automatically determined

	A
0	42
1	100
2	310
3	44
4	55
5	0
6	3
7	4
8	0
9	99

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Arrays

- Array Initialization
 - Static initialization at time of array definition
 - Initial elements listed in { }

- Example:

```
int A[10] = { 1, 2, 3};
```

- With given initializer list *and* array size, unlisted elements are zero-initialized
 - array is filled up with zeros

	A
0	1
1	2
2	3
3	0
4	0
5	0
6	0
7	0
8	0
9	0

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Arrays

- Multi-dimensional Arrays
 - Array of an array...
- Example:

```
int M[3][2] = {{1, 2},
               {3, 4},
               {5, 6}};

int i, j;

for(i=0; i<3; i++)
  { for(j=0; j<2; j++)
    { printf("%d ",
             M[i][j]);
      }
    printf("\n");
  }
```

M	0	1
0	1	2
1	3	4
2	5	6

```
1 2
3 4
5 6
```

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Arrays

- Operator associativity and precedence
 - parentheses, array access (), [] left to right
 - unary operators +, -, !, ++, -- right to left
 - type casting (*typename*) right to left
 - multiplication, division, modulo *, /, % left to right
 - addition, subtraction +, - left to right
 - shift left, shift right <<, >> left to right
 - relational operators <, <=, >=, > left to right
 - equality ==, != left to right
 - logical and && left to right
 - logical or || left to right
 - conditional operator ?: left to right
 - assignment operators =, +=, *=, etc. right to left
 - comma operator , left to right

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Arrays

- Program example: `Histogram.c`
 - Display a simple bar graph for 10 integer values
- Desired output:

```
% Histogram
Please enter data value 1: 111
Please enter data value 2: 222
Please enter data value 3: 33
Please enter data value 4: 333
[...]
Please enter data value 10: 111
1: 111 *****
2: 222 *****
3: 33 ****
4: 333 *****
[...]
10: 111 *****
%
```

Arrays

- Program example: `Histogram.c` (part 1/3)

```
/* Histogram.c: print a histogram of data values */
/* author: Rainer Doemer */
/* modifications: */
/* 11/02/04 RD initial version */

#include <stdio.h>

/* constants */
#define NUM_ROWS 10

/* main function */
int main(void)
{
    /* variable definitions */
    int Data[NUM_ROWS];
    int i, j, max;
    double scale;

    ...
}
```

Arrays

- Program example: `Histogram.c` (part 2/3)

```

...
/* input section */
for(i = 0; i < NUM_ROWS; i++)
{ printf("Please enter data value %2d: ", i+1);
  scanf("%d", &Data[i]);
} /* rof */

/* computation section */
max = 0;
for(i = 0; i < NUM_ROWS; i++)
{ if (Data[i] > max)
  { max = Data[i];
    } /* fi */
} /* rof */
scale = 70.0 / max;
...

```

Arrays

- Program example: `Histogram.c` (part 3/3)

```

...
/* output section */
for(i = 0; i < NUM_ROWS; i++)
{ printf("%2d: %5d ", i+1, Data[i]);
  for(j = 0; j < Data[i]*scale; j++)
  { printf("");
    } /* rof */
  printf("\n");
} /* rof */

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

/* EOF */

```


Arrays

- Example session: `Histogram.c`

```
% vi Histogram.c
% gcc Histogram.c -o Histogram -Wall -ansi
% Histogram
Please enter data value 1: 11
Please enter data value 2: 22
Please enter data value 3: 3
Please enter data value 4: 33
Please enter data value 5: 44
Please enter data value 6: 55
Please enter data value 7: 66
Please enter data value 8: 33
Please enter data value 9: 22
Please enter data value 10: 22
1: 11 *****
2: 22 *****
3: 3 ****
4: 33 *****
5: 44 *****
6: 55 *****
7: 66 *****
8: 33 *****
9: 22 *****
10: 22 *****
%
```

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