CS113: Lecture 7

Topics:

- typedef, struct
- Introduction to Pointers
Create your own types: typedef

#define N 3

typedef double scalar; /* note defs outside fns */
typedef scalar vector[N];

typedef scalar matrix[N][N];
/* alternatively:
   typedef vector matrix[N]; */

/* add(x,y,z) adds the vectors y and z,
   placing the result in x */
void add( vector x, vector y, vector z )
{
    int i;
    for( i = 0; i < N; i++ )
    {
        x[i] = y[i] + z[i];
    }
}
Structures

- The structure mechanism allows us to aggregate variables of different types

- `struct` definitions generally go outside of the functions, as in the following example

```c
struct card_struct
{
    int pips;
    char suit;
};

typedef struct card_struct card;

void some_function()
{
    struct card_struct a;
    card b; /* a, b have the same type */

    b.pips = 3;
    b.suit = 'D';
    a = b;
}
```
struct example: points in the plane

#include <math.h>

struct point_struct
{
    double x;
    double y;
};

typedef struct point_struct point;

double distance( point p1, point p2 )
{
    double dx, dy, dist;
    dx = p1.x - p2.x;
    dy = p1.y - p2.y;
    dist = sqrt((dx * dx) + (dy * dy));
    return( dist );
}

void main()
{
    point a = { 3.5, 4.5 };  
    point b = { 6.5, 0.5 };  
    printf( "distance: %f\n", distance( a, b ));
}
Introduction to Pointers

- A variable in a program is stored in a certain number of bytes at a particular memory location, or address, in the machine.

- Pointers allow us to manipulate these addresses explicitly.

- To declare a pointer variable: add a star to the type you want to point to. Example:
  ```
  int *a;
  ```
  declares a variable a of type int *, which can be used to hold the address of (or a “pointer to”) an int.

- Two unary operators (“inverses”):
  - & operator - “address of” operator. Can be applied to any variable. Type of resulting expression has “one more star” than original expression.
  
  - * operator - “dereference” operator. Can be applied only to pointers. Accesses the object that the pointer points to. Type of resulting expression has “one less star” than original expression.

- Don’t confuse the * operator with the * in the declaration of a variable (nor with multiplication).
Pointers: Example

```c
int x = 1, y = 2;
int *ip;
char c;
char *cp;

ip = &x;    /* ip now points to x */
printf( "%d\n", *ip );    /* 1 */
printf( "%d\n", *ip + 2 );    /* 3 */
y = *ip;    /* y is now 1 */
*ip = 0;    /* x is now 0 */

printf( "%d\n", x );    /* 0 */

cp = &x;    /* doesn’t work; types don’t match */
*cp = 'z';    /* what happens? */

printf( "%c\n", c );    /* z */
```
printf vs. scanf

void main()
{
    int k;
    printf( "Enter an integer: " );
    scanf( "%d", &k );
    printf( "%d", k );
}

Also works:

void main()
{
    int k, *pk;
    pk = &k;
    printf( "Enter an integer: " );
    scanf( "%d", pk );
    printf( "%d", k );
}

Who wants what information?

- `printf( "%d", ... );` expects an int, since it needs to know what to print out
- `scanf( "%d", ... );` expects the address of an int, since it needs to know where to place the int typed in
  - `scanf` doesn’t care about the actual value of the int that it should write to
More practice

```c
void main()
{
    int a = 3, b = 3;
    int *pa, *pb;

    pa = &a;
    pb = &b;

    if( pa == pb )
        printf( "pa and pb are equal.\n" );
    if( *pa == *pb )
        printf( "*pa and *pb are equal.\n" );

    (*pa)++; /* careful: different from *pa++ */
    *pb += *pa;
    printf( "a: %d, b: %d\n", a, b );

    pb = pa;
    *pa += *pb;
    printf( "a: %d, b: %d\n", a, b );
    if( pa == pb )
        printf( "pa and pb are equal.\n" );
    if( *pa == *pb )
        printf( "*pa and *pb are equal.\n" );
}
```
How to swap two values?

What's wrong with this?

```c
void swap( int x, int y )
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}

void main()
{
    int a = 3, b = 5;
    swap( a, b );
    printf( "a is %d, b is %d\n", a, b );
}
```
A correct swap

```c
void swap( int *px, int *py )
{
    int temp;

    temp = *px;
    *px = *py;
    *py = temp;
}

void main()
{
    int a = 3, b = 5;
    swap( &a, &b );
    printf( "a is %d, b is %d\n", a, b );
}
```
Be careful with your new toys.

- Do not point at constants.

```c
int *ptr;
ptr = &3; /* illegal */
```

- Do not point at expressions that are not variables.

```c
int k = 1, *ptr;
ptr = &(k + 99); /* illegal */
```

- Do not try to dereference non-pointer variables.

```c
int k;
printf( "%d", *k ); /* illegal */
```

- What's wrong with this?

```c
int *function_3()
{
    int b;
    b = 3;
    return &b;
}

void main()
{
    int *a;
    a = function_3();
    printf( "a is equal to %d\n", *a );
}
An example

Good to know the right-hand rule.

```c
void main()
{
    int a, b;
    int *pc, *pd;
    int **ppe, **ppf;
    a = 3;
b = 5;
p = &a;
pd = &b;
(*pd)++;
printf( "a: %d b: %d\n", a, b );
*pc += *pd;
printf( "a: %d b: %d\n", a, b );
ppe = &pc;
ppf = &pd;
*ppf = pc;
*pd = 12;
printf( "a: %d b: %d\n", a, b );

**ppe = 50;
**ppf = 15;
printf( "a: %d b: %d\n", a, b );
}
```