CS106X
Spring 99-00

Handout #24
April 26, 2000

Examples of Procedural Recursion

This handout contains code for the file reverse, Sierpinski triangle fractal, the Towers of Hanoi, and the knapsack tape-fitter. Having the printed code is intended to make it easier to follow in class, but as these examples are somewhat sparsely commented, you should make sure to keep up with the discussion in lecture. The tower example is fully covered in your textbook as well.

The implementation of **`ReverseFile`** looks like this:

```
void ReverseFile(FILE *in, FILE *out)
{
    int ch;

    if ((ch = getc(in)) != EOF) {
        ReverseFile(in, out);
        putc(ch, out);
    }
}
```

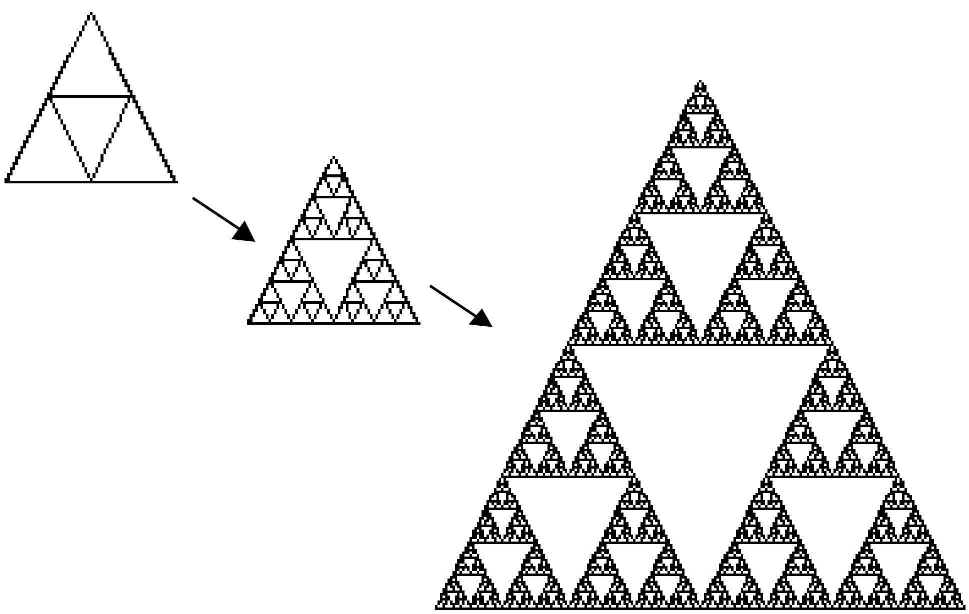
```
#define TooSmall 0.2  /* size at which hits base case */

/*
 * FractalTriangle
 * ---------------
 * A recursive Sierpinski graphic.  The version draws the outer triangle
 * first and then recurs for the three smaller triangles.  Alternatively,
 * we could make the recursive calls and then draw the outer triangle-- the
 * final picture would be the same either way, but the pattern in which the
 * drawing materialized would be different. The base case is when we have a
 * triangle too small to recursively dissect, in which case we just draw
 * the triangle and stop.
 */
static void FractalTriangle(double x, double y, double width, double height)
{
     double halfH = height/2, halfW = width/2;

     DrawTriangle(x, y, width, height);
     if (width < TooSmall || height < TooSmall) return; // stop here

     FractalTriangle(x, y, halfW, halfH);                        // left
     FractalTriangle(x + halfW/2,y + halfH, halfW, halfH);    // top
     FractalTriangle(x + halfW, y, halfW, halfH);             // right
}

static void DrawTriangle(double x, double y, double width, double height)
{
     MovePen(x, y);
     DrawLine(width, 0);
     DrawLine(-width/2.0, height);
     DrawLine(-width/2.0, -height);
 }
```



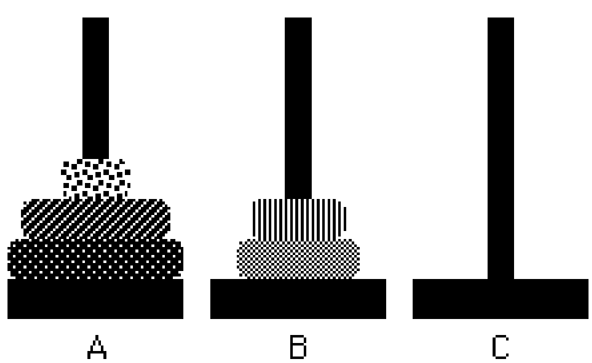
```
/*
 * File: hanoi.c
 * -------------
 * This program implements a tower-moving algorithm based on the classic
 * Towers of Hanoi problem.  We've got a stack of graduated disks to move from
 * Peg A to Peg C, with one intermediate storage Peg B. The rules are that
 * we can only move one disk at a time and we can only stack a disk on top
 * of a larger disk. We show the progress by printing each time we move
 * a disk from tower to tower.
 */

static void MoveTower(int height, char source, char dest, char temp);
static void MoveSingleDisk(char source, char dest);

main()
{
      MoveTower(5, 'A', 'B', 'C');
}


/*
 * Function: MoveTower
 * -------------------
 * Function to move a tower of height from the source peg to destination peg
 * using temp as intermediate storage, following the rules of the game.
 * We take the recursive leap of faith and assume we can move off the top n-1
 * disks from source to temp using destination as intermediate, then move the
 * bottommost disk from source to dest, then recursively pile on the n-1 tower
 * we earlier moved aside.  Our base case is the empty tower, 0 disks, which
 * requires no work.  The single height tower is handled just as any other
 * recursive call (make things as simple as possible!)
*/
static void MoveTower(int height, char source, char dest, char temp)
{
      if (height > 0) {
         MoveTower(height-1, source, temp, dest);
         MoveSingleDisk(source, dest);
         MoveTower(height-1, temp, dest, source);
      }
}

static void MoveSingleDisk(char source, char dest)
{
      printf("Moving disk from %c to %c\n", source, dest);
}
```



```
 /*
  * File: knap.c
  * ------------
  * This program implements a tape-packing algorithm based on the classic
  * CS knapsack problem.  For each song, we consider the tape with that
  * song on or not and in each case recursively compute the best fit
  * from that configuration to decide whether the song stays or goes.
  */
#include <stdio.h>
#include "genlib.h"

#define LENGTH_OF_TAPE 30
#define NUM_SONGS 10

static double MinimumWaste(double songs[], int numSongs, double spaceLeft);

void main()
{
    /* Shorthand way to initialize an array, here for convenience */
    double minWaste, album[NUM_SONGS] = {3.12, 4.55, 3.56, 3.12, 4.01,
                                         3.55, 2.59, 3.25, 4.44, 2.54};

    minWaste = MinimumWaste(album, NUM_SONGS , LENGTH_OF_TAPE);
    printf("Total tape time will be %g \n", LENGTH_OF_TAPE - minWaste);
}


/*
 * Function: MinimumWaste
 * ---------------------
 * Function to compute minimum waste for tape collection using a exhaustive
 * recursive search procedure.  We consider one song on each invocation. We
 * first compute the minimum waste assuming the song is NOT added to the
 * tape. Then we will try with song to see what best we can do.
 * Compare the two to see which was better and return that as the best
 * we found.   Note that if there isn't enough space to try with the song
 * on the tape, we just return what we can do without it.
 * We hit base case where there are no more songs to try and place on
 * the tape.
 */
static double MinimumWaste(double songs[], int numSongs, double spaceLeft)
{
    double withSong, withoutSong;

    if (numSongs <= 0)      // Base case:  no more songs, stop here
       return spaceLeft;

    withoutSong = MinimumWaste(songs + 1, numSongs - 1, spaceLeft);
    if (spaceLeft < songs[0]) return withoutSong;  // can't fit this song
    withSong = MinimumWaste(songs + 1, numSongs -1, spaceLeft - songs[0]);

    return ((withSong < withoutSong) ? withSong : withoutSong));
}
```