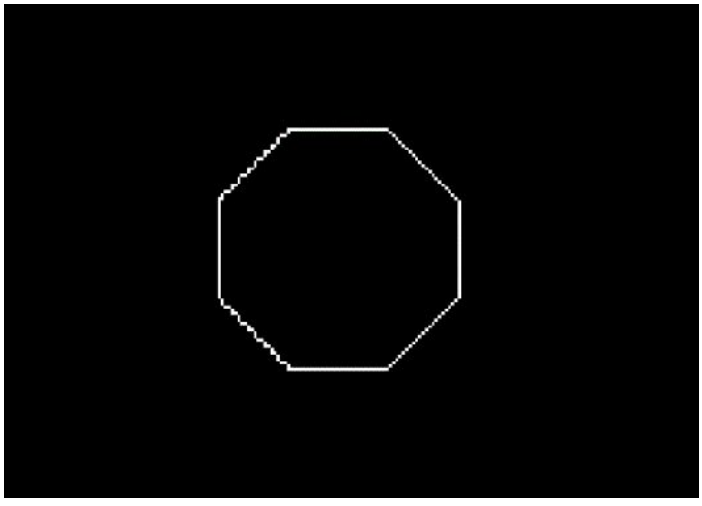
12.3 Turtle Graphics

History

- Many attempts have been made to create programming languages which are intuitive and easy to learn.
- One of the best of these was *LOGO* which allowed children as young as 3 to learn a computer language.
- A subset of this language involved a "turtle" which could be driven around the screen using simple instructions. The turtle, when viewed from above, was represented by a triangle.

An Example

```
{
 FD 30
 LT 45
 FD 30
 LT 45
 FD 30
 LT 45
 FD 30
 LT 45
 FD 30
 LT 45
 FD 30
 LT 45
 FD 30
 LT 45
 FD 30
 LT 45
}
```



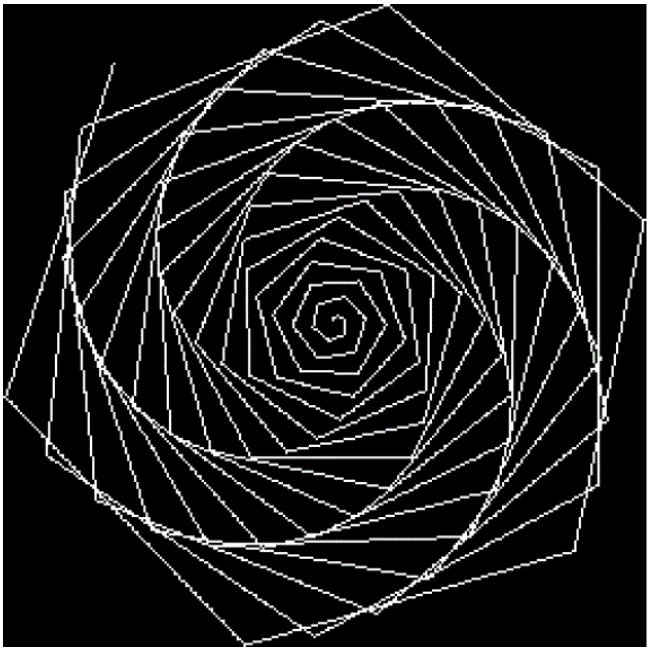
Adding Loops

```
{
   DO A FROM 1 TO 8 {
      FD 30
```

```
        LT 45
    }
}
```

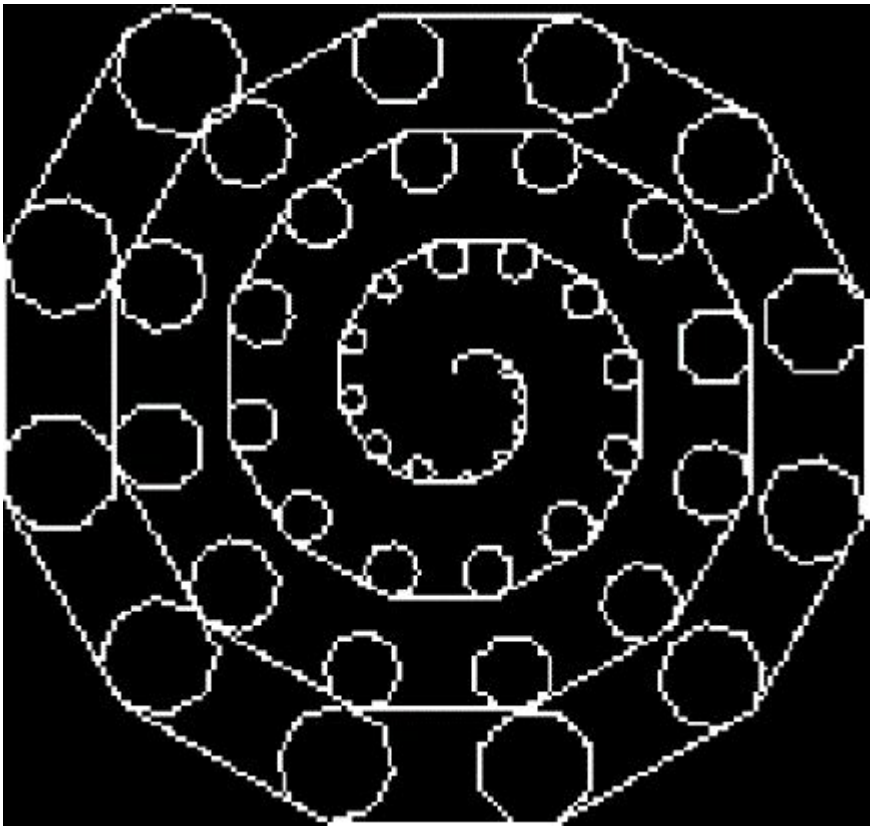
Using Variables

```
{
    DO A FROM 1 TO 100 {
        SET C := A 1.5 * ;
        FD C
        RT 62
    }
}
```



Nested Loops

```
{
    DO A FROM 1 TO 50 {
        FD A
        RT 30
        DO B FROM 1 TO 8 {
            SET C := A 5 / ;
            FD C
            RT 45
        }
    }
}
```



The Formal Grammar

```
<MAIN> ::= "{" <INSTRCTLST>
<INSTRCTLST> ::= <INSTRUCTION><INSTRCTLST> |
                 "}"
<INSTRUCTION> ::= <FD> |
                  <LT> |
                  <RT> |
                  <DO> |
                  <SET>
<FD> ::= "FD" <VARNUM>
<LT> ::= "LT" <VARNUM>
<RT> ::= "RT" <VARNUM>
<DO> ::= "DO" <VAR> "FROM" <VARNUM> "TO"
                  <VARNUM> "{" <INSTRCTLST>
<VAR> ::= [A−Z]
<VARNUM> ::= number | <VAR>
<SET> ::= "SET" <VAR> ":=" <POLISH>
<POLISH> ::= <OP> <POLISH> | <VARNUM> <POLISH> | ";"
<OP> ::= "+" | "−" | "∗" | "/"
```

Exercise 12.3 Implement a recursive descent parser - this will report whether or not a given turtle program follows the formal grammar or not. The input file is specified via `argv[1]` - there is **no** output if the input file is **valid**. Elsewise, a non-zero `exit` is made.

Extend the parser, so it becomes an interpreter. The instructions are now 'executed'. Do

not write a new program for this, simply extend your existing parser. Output is via SDL. You may find the function call `SDL_RenderDrawLine` useful.

Show a testing strategy on the above - you should give details of unit testing, white/black-box testing done on your code. Describe any test-harnesses used. In addition, give examples of the output of many different turtle programs. Convince me that every line of your C code has been tested.

Show an extension to the project in a direction of your choice. It should demonstrate your **understanding** of some aspect of programming or S/W engineering. If you extend the formal grammar make sure that you show the new, full grammar.

Hints

- All four sections above are equally weighted.
- Don't try to write the entire program in one go. Try a cut down version of the grammar first, e.g.:

```
<MAIN>        ::= "{" <INSTRCTLST>
<INSTRCTLST>  ::= <INSTRUCTION><INSTRCTLST> |
                  "}"
<INSTRUCTION> ::= <FD> | <LT> | <RT>
<FD>          ::= "FD" <VARNUM>
<LT>          ::= "LT" <VARNUM>
<RT>          ::= "RT" <VARNUM>
<VARNUM>      ::= number
```

- The language is simply a sequence of words (even the semi-colons), so use `fscanf()`.
- Some issues, such as what happens if you use an undefined variable, or if you use a variable before it is set, are not explained by the formal grammar. Use your own common-sense, and explain what you have done.
- Once your parser works, extend it to become an interpreter. DO NOT aim to parse the program first and then interpret it separately. Interpreting and parsing are inseparably bound together.
- Start testing very early - this is a complex beast to test and trying to do it near the end won't work.

Submission

Your testing strategy will be explained in `testing.txt`, and your extension as `extension.txt`. For the parser, interpreter and extension sections, make sure there's a `Makefile`, so that I can easily build the code using `make parse`, `make interp` and `make extension`. Submit a single `turtle.zip` file.

■

12.4 The UNIX awk program

Sometimes handling files containing numerical data in C may be somewhat arduous. A 'simple' program to swap the first and second columns of a file is quite long in C.

For this reason, there is a simple language called awk which allows simple manipulation to be done on a line by line basis. For example:

```
{
print $2, $1;
}
```