CS101 Computer Programming and Utilization

Milind Sohoni

May 12, 2006

1. Control Flow in C++ programs

The story so far ...

We have seen elementary C++ programs and its functionalities such as:

- Variables, Assignments and Declarations.
- The basic program structure.
- Basic Input and Output.
- The If-else statement.

More Control Flows

Our objective is now to understand more intricate control-flows. Again www.cplusplus.com/doc/tutorial for reference.

The do-while

This program mylog.c computes largest a such that $10^a < N$.

```
#include <iostream.h>
// estimate log
int main()
{
  int N,a,b;
  cout << "N?" << "\n";
  cin >> N;
  a=0; // this is the log
  b=1; // estimate to N
  do
  {
    a=a+1;
    b=b*10;
  }
  while (b<N);
  cout << a << "\n";
  return 0;
}
```

The do-while

```
#include <iostream.h>
// estimate log
int main()
{
  int N,a,b;
  cout << "N?" << "\n";
  cin >> N;
  a=0; // this is the log
  b=1; // estimate to N
  do
  {
    a=a+1;
    b=b*10;
  }
  while (b<N);
  cout << a << "\n";
  return 0;
}
```

This program mylog.c computes largest a such that $10^a < N$.
The basic structure is:

```
prevline;
do
{
   codeblock
}
while (cond);
nextline;
```

The do-while

```
#include <iostream.h>
// estimate log
int main()
{
  int N,a,b;
  cout << "N?" << "\n";
  cin >> N;
  a=0; // this is the log
  b=1; // estimate to N
  do
  {
    a=a+1;
    b=b*10;
  }
  while (b<N);
  cout << a << "\n";
  return 0;
}
```

This program mylog.c computes largest a such that $10^a < N$.
The basic structure is:

```
prevline;
do
{
   codeblock
}
while (cond);
nextline;
```

The execution ...

- When the do statement is encountered, a note is made of the line number.
  Execution continues

The do-while

```
#include <iostream.h>
// estimate log
int main()
{
  int N,a,b;
  cout << "N?" << "\n";
  cin >> N;
  a=0; // this is the log
  b=1; // estimate to N
  do
  {
    a=a+1;
    b=b*10;
  }
  while (b<N);
  cout << a << "\n";
  return 0;
}
```

The basic structure is:

```
prevline;
do
{
   codeblock
}
while (cond);
nextline;
```

The execution ...

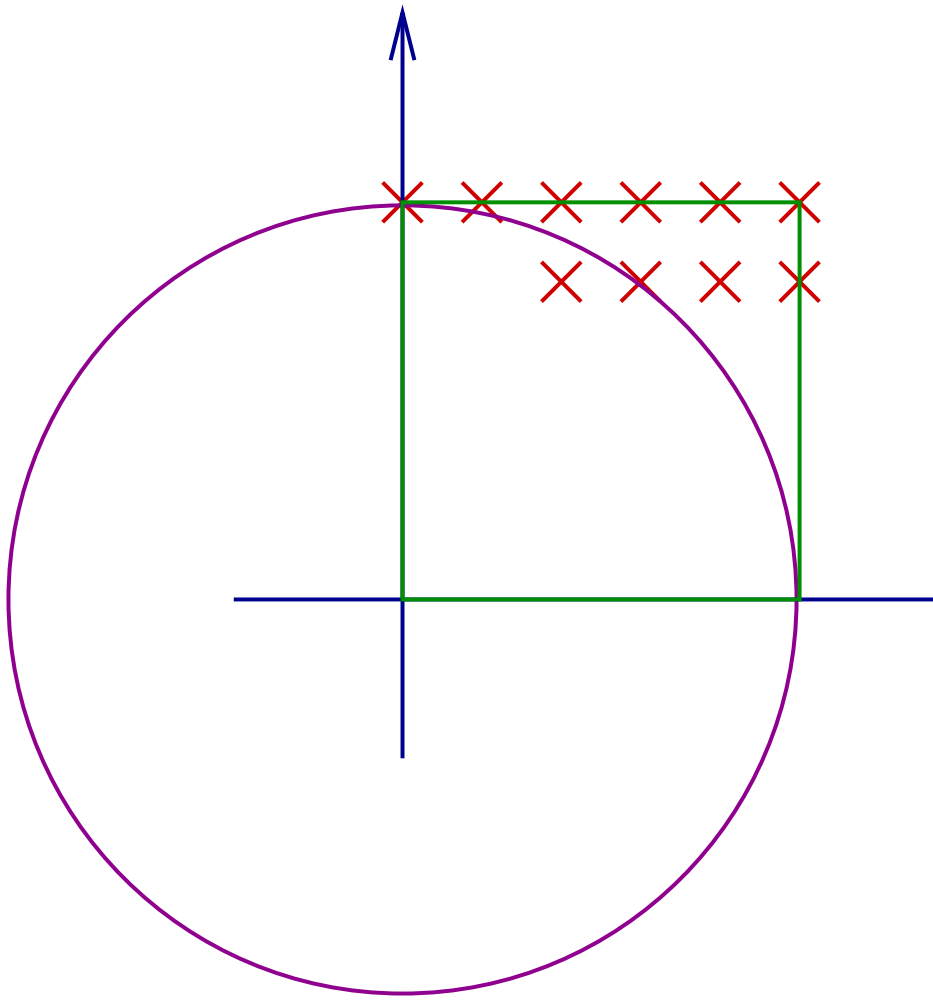
- After the execution of code block, the while and condition ($b < a$) is seen and evaluated. If this condition evaluates to true, the execution goes back to do.
- If false execution goes to the next line.

Estimating π: pi.c

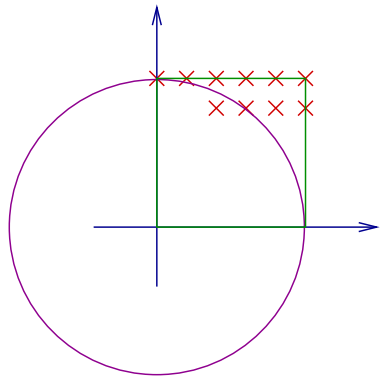
```
#include <iostream.h>
// estimate pi
int main()
{
  int N,count;
  float pi,r,delta,x,y;
  cout << "N?" << "\n";
  cin >> N;
  x=1; y=1; count=0;
  delta=1.0/N;
    count all grid points
    in unit circle
  pi=4.0*count/(N*N);
  cout << pi << "\n";
  return 0;
}
```

Estimating π: pi.c

```
#include <iostream.h>
// estimate pi
int main()
{
  int N,count;
  float pi,r,delta,x,y;
  cout << "N?" << "\n";
  cin >> N;
  x=1; y=1; count=0;
  delta=1.0/N;
    count all grid points
    in unit circle
  pi=4.0*count/(N*N);
  cout << pi << "\n";
  return 0;
}
```



Estimating π: pi.c



```
#include <iostream.h>
// estimate pi
int main()
{
  int N,count;
  float pi,r,delta,x,y;
  cout << "N?" << "\n";
  cin >> N;
  x=1; y=1; count=0;
  delta=1.0/N;
    count all grid points
    in unit circle
  pi=4.0*count/(N*N);
  cout << pi << "\n";
  return 0;
}
```

```
do
  {
  x=1;
  do
    {
     r=1-x*x-y*y;
     if (r>0) count=count+1;
     x=x-delta;
    }
  while (x>0);
  y=y-delta;
  }
while (y>0);
```

The more common-while loop

Estimating log (again): `mylog2.c`

```
#include <iostream.h>
// estimate log
int main()
{
  int N,a,b;
  cout << "N?" << "\n";
  cin >> N;
  a=0; // this is the log
  b=1; // estimate to N
  while (b<N)
  {
    a=a+1;
    b=b*10;
  };
  cout << a << "\n";
  return 0;
}
```

Usually, the `while` loop below is more prevalent. Basic structure:

```
prevline;
while (cond)
{
  code block
};
nextline;
```

The difference between the do-while and the while is that the condition is evaluated before the loop is entered. Thus, `mylog2.c` returns 0 for input 1 while `mylog.c` makes an error.

The for loop

Execution: fire.c

```
#include <iostream.h>
// countdown using a for loop
// from www.cpluscplus.com
int main ()
{
  int n;
  for (n=10; n>0; n=n-1) {
    cout << n << ", ";
  }
  cout << "FIRE!";
  return 0;
}
```

The for loop

Execution: fire.c

```
#include <iostream.h>
// countdown using a for loop
// from www.cpluscplus.com
int main ()
{
  int n;
  for (n=10; n>0; n=n-1) {
    cout << n << ", ";
  }
  cout << "FIRE!";
  return 0;
}
```

The for loop has four parts:

```
for (init;condn;assignment)
{
  body
}
```

The for loop

Execution: `fire.c`

```
#include <iostream.h>
// countdown using a for loop
// from www.cpluscplus.com
int main ()
{
  int n;
  for (n=10; n>0; n=n-1) {
    cout << n << ", ";
  }
  cout << "FIRE!";
  return 0;
}
```

The for loop has four parts:

```
for (init;condn;assignment)
{
  body
}
```

- The init is the initialization of the looping variable. This is done only once when the statement is first encountered.
- The condn is checked everytime, and if true, the body is entered.
- Everytime, but the first, the assignment is executed, which hopefully changes the looping variable.
- Note that the looping variable is also available in side the body.

π again: pi2.c

```
#include <iostream.h>
// estimate pi
int main()
{
  float pi;
  int i,j,N,count;
  cout << "N?" << "\n";
  cin >> N;
  count=0;
  for (i=1;i<=N;i=i+1){
    for (j=1;j<=N;j=j+1){
     if (i*i+j*j<=N*N)
       count=count+1;
    };
  };
  pi=4.0*count/(N*N);
  cout << pi << "\n";
  return 0;
}
```

Main features:

- Two nested for loops.
- Note the two variables i,j must be declared, initialized, checked and updated.
- Structure, much much simpler.

π again: pi2.c

```
#include <iostream.h>
// estimate pi
int main()
{
  float pi;
  int i,j,N,count;
  cout << "N?" << "\n";
  cin >> N;
  count=0;
  for (i=1;i<=N;i=i+1){
    for (j=1;j<=N;j=j+1){
     if (i*i+j*j<=N*N)
       count=count+1;
    };
  };
  pi=4.0*count/(N*N);
  cout << pi << "\n";
  return 0;
}
```

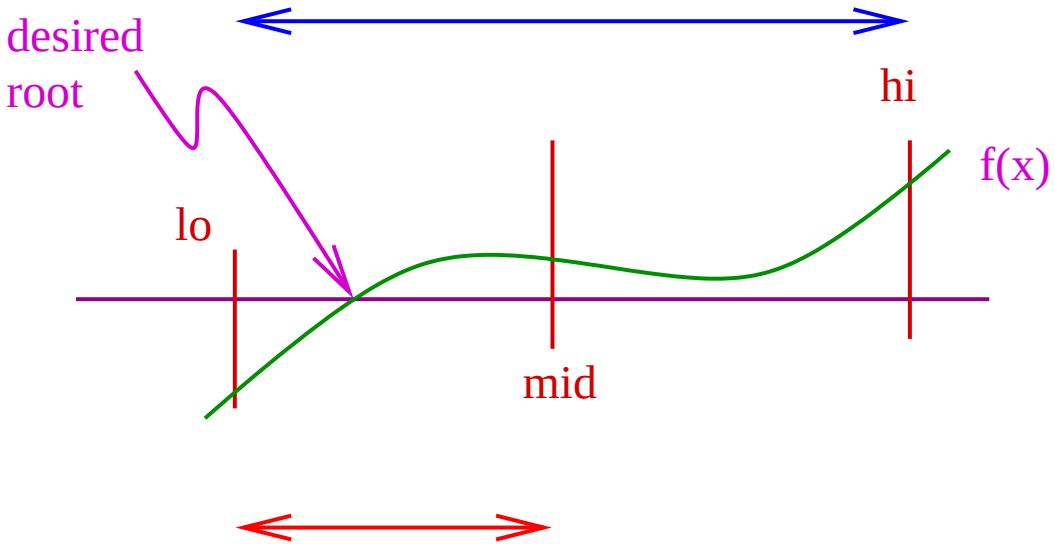
Main features:

- Two nested for loops.
- Note the two variables i,j must be declared, initialized, checked and updated.
- Structure, much much simpler.

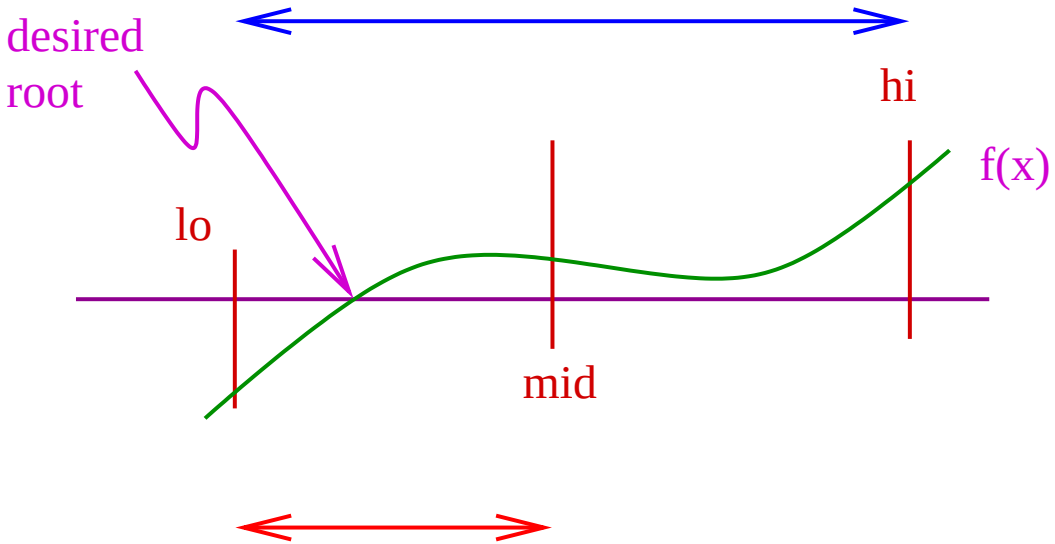
Assignment

- Write a program which takes in N reals numbers and prints out the mean and variance.
- Use the expansion of e and compute an approximation to the value of e.

Root Finding



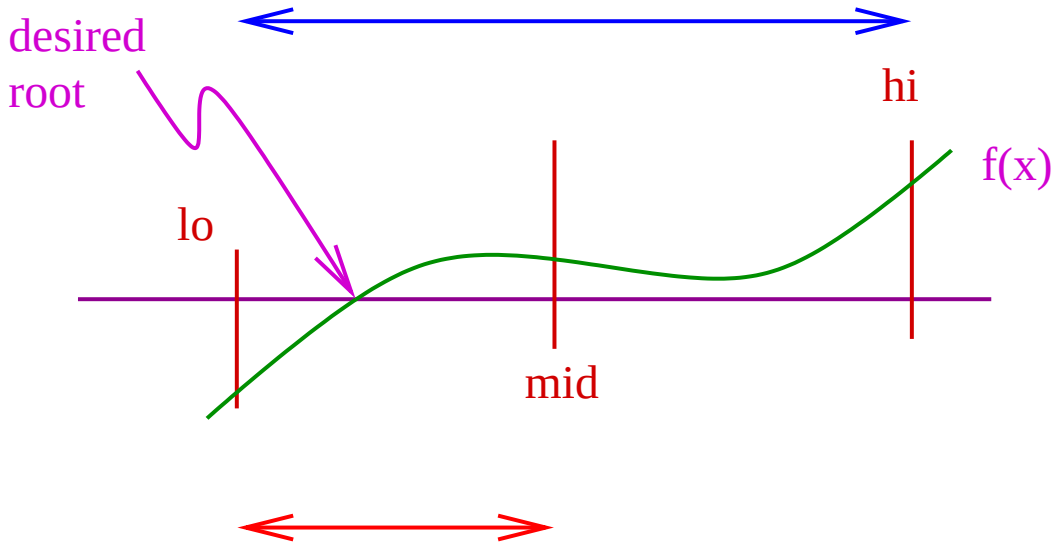
Root Finding



The Bisection Method

- Start with a lo and hi values such that $f(lo) * f(hi) < 0$.
- Compute mid and $f(mid)$.
- while $|f(mid)| > tol$, locate the next interval to be either [low,mid] or [mid,hi].

Root Finding



The Bisection Method

- Start with a lo and hi values such that $f(lo) * f(hi) < 0$.
- Compute mid and $f(mid)$.
- while $|f(mid)| > tol$, locate the next interval to be either [low,mid] or [mid,hi].

We write a program to solve cubics $Ax^3 + Bx^2 + Cx + D$.

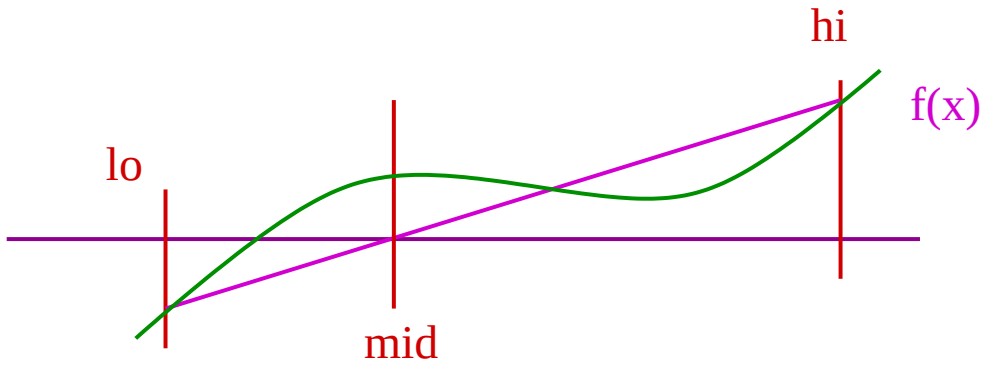
- Takes in inputs A,B,C,D.
- Takes in inputs lo,hi, tol. Returns if $f(lo) * f(hi) > 0$.
- Sets up the while loop and returns mid so that $|f(mid)| < tol$.

cubicroot.c

```
#include <iostream.h>
int main()
{
  float A,B,C,D,lo,hi,mid,flo,fhi,fmid;
  float tol;
  cout << "A B C D ?" << "\n";
  cin >> A >> B >> C >> D;
  cout << "low high tolerance" << "\n";
  cin >> lo >> hi >> tol;
  flo=A*lo*lo*lo +B*lo*lo +C*lo +D;
  fhi=A*hi*hi*hi +B*hi*hi +C*hi +D;
  if (flo*fhi>0)
  {
   cout << "error in hi-lo" << "\n";
   return 1;
  };
   THE MAIN PART
 cout << mid << "\n";
 return 0;
}
```

```
mid=(lo+hi)/2;
fmid=A*mid*mid*mid +B*mid*mid +C*mid +D;
while (fabs(fmid)>tol)
  {
   if (flo*fmid >0)
   {
     lo=mid;
     flo=fmid;
   }
   else
   {
     hi=mid;
     fhi=fmid;
   };
   mid=(lo+hi)/2;
   fmid=A*mid*mid*mid +B*mid*mid +C*mid +D;
}; // end of while
```

The Secant Method



assignment

- The secant method computes mid in a different way. It takes mid as the point where the line joining the low and the high values, as shown in the figure above. Write a C++ program to implement the secant method of computing the roots of a degree 5 polynomial. Input the coefficients of the polynomial, hi and lo values, a tolerance and a a bound N on the number of iterations.