CS101 Computer Programming and Utilization

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The story so far ...

- We have seen various control flows.
- We have seen multi-dimensional arrays and the `char` data type.
- We saw the use of functions and calling methods.

This week...

Introduction to Classes

Class

The basic objective of classes were

- to generalize type declarations such as `int`,`float` to user-defined types such as `poly`, `matrix`.
- to separate the user from the implementer. Thus, e.g., I may write polynomials class and various operations on it such as evaluation, differentiation etc. Any other user may use my polynomial definition. She must however use it only through the operations that I allow.

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The Class framework is a special feature of C++.

- The class definition contains of two main chunks:
  - The private definition (or member variables),
  - The public operations.
- The private cconcerns details about the representation,
- The public defines operations which are exposed to the outside.

The poly.cpp class

```
#include <iostream.h>
#include <math.h>
class poly
{
   private:
    float coefs[10];
    int   degree;


   public:
    void ReadIn(void);
    int  deg(void);
    float eval(float);
//    poly diff(void);


   };
;
```

```
void poly::ReadIn(void)
{
   cin>> degree;
   if (degree >9)
      cout << "degree bounded by
   for (int i=0;i<=degree;i=i+1)
      cin >> coefs[i];
}
int poly::deg(void)
{
   return degree;
}
float poly::eval(float x)
{
   float r;
   r=0;
   for (int i=0;i<=degree;i=i+1)
     r=r+pow(x,i)*coefs[i];
   return r;
}
```

The poly.cpp class

```
class poly
{
   public:
    void ReadIn(void);
    int  deg(void);
    float eval(float);
//    poly diff(void);
};

int main()
{
  poly p;
  p.ReadIn();
  cout << p.eval(1.0);
}
```

```
[sohoni@nsl-13]$ ./a.out
3
1 2 3 4

10
```

Thus `p.ReadIn()` causes the construction of the polynomial

$$p = 1 + 2x + 3x^2 + 4x^3$$

The next statement `p.eval(1.0)` evaluates it at $x = 1$.

The class structure

The basic structure of a program using classes is as follows:

```
# include ...
class classname
{
  private ...;

  public  ...;
};


void classname::function
{
   body
}
```

The class definition has two parts and must be done before the main program begins.

- The Declaration, which declare the class name, the private or member variables and the methods, which are the public ways of accessing objects.
- The Methods, which are the definition of the functions which operate on the local variables. These are the only methods by which an outer program may access the member variables.

Uses

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}
```

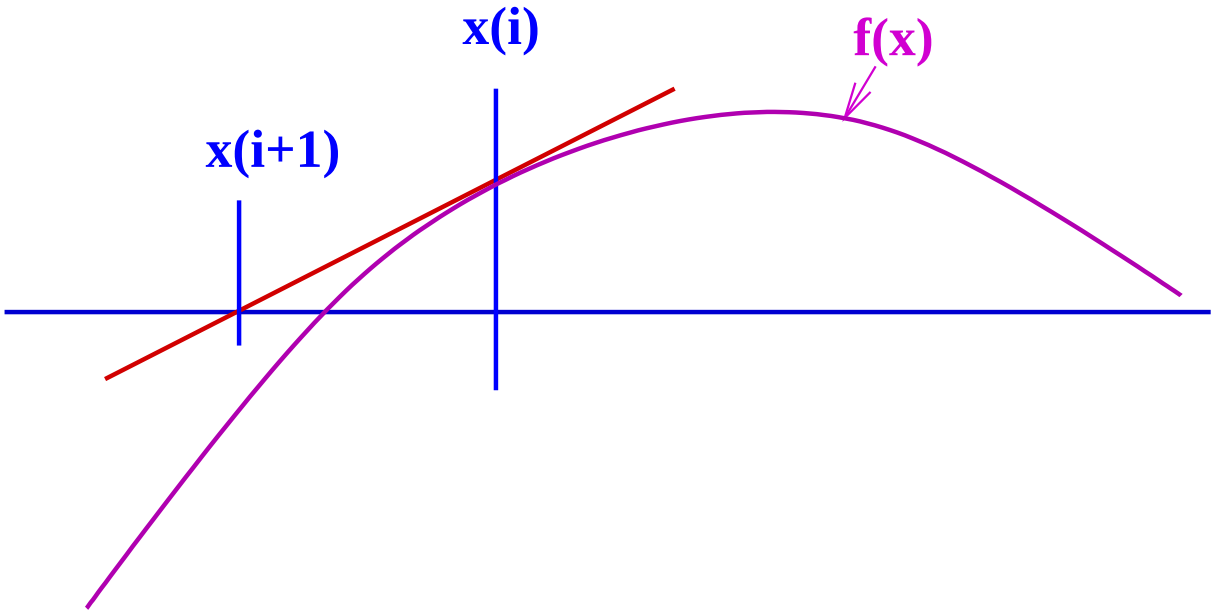
The main uses of classes are:

- As opposed to struct, a class allows not only data but procedures which manipulate this data.
- This allows a separation: the person who writes the class may be different from the one who uses it.
- Classes allow us to remember data: coefs read only once, but polynomial evaluated repeatedly.

Root finding again

The Newton-Raphson technique:

- Use the function value and its derivative to compute the next candidate.



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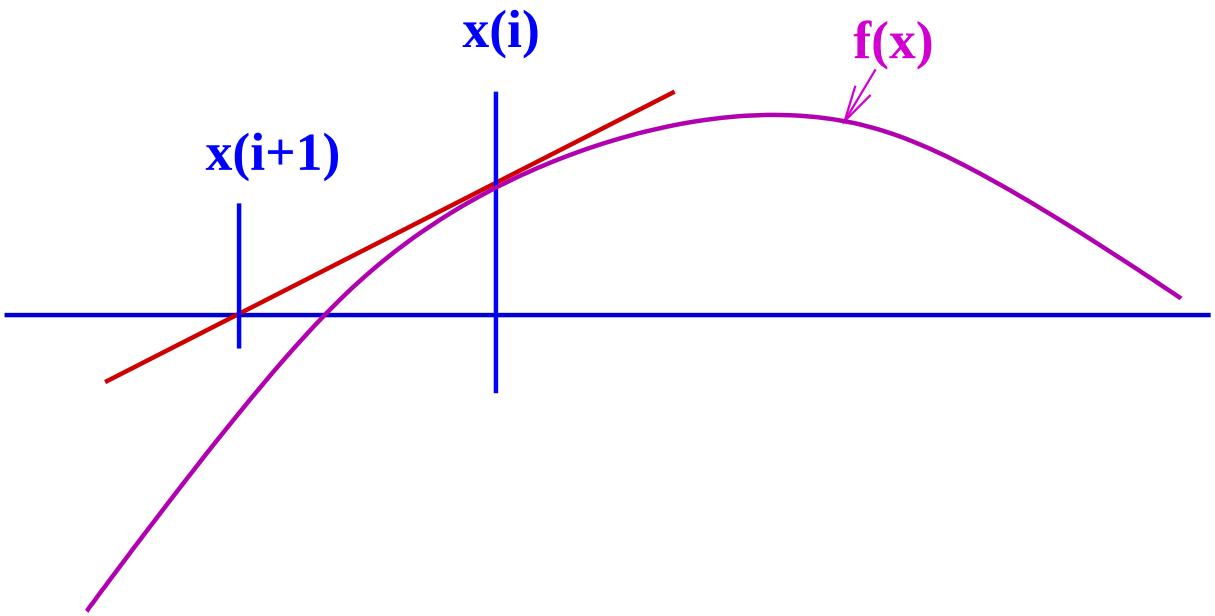

- $x_{i+1} = x_i - (f(x_i)/f'(x_i))$.

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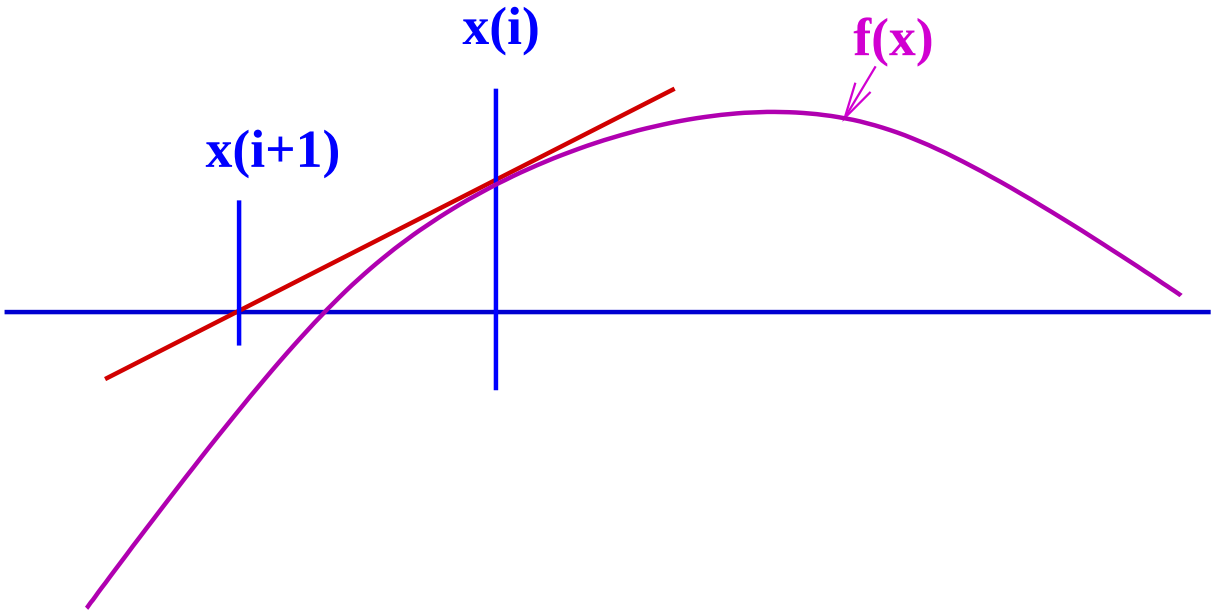

- $x_{i+1} = x_i - (f(x_i)/f'(x_i))$.
- We will upgrade out poly class to include differentiation.

newraph.cpp

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class poly
{
   private:
    float coefs[10];
    int   degree;
   public:
    void ReadIn(void);
    int  deg(void);
    float eval(float);
    poly diff(void);
};
```

This allows yet another public function called p.diff() on a polynomial p.

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This allows yet another public function called p.diff() on a polynomial p.

And here is the definition of p.diff.

```
poly poly::diff(void)
{
   poly q;
   q.degree=degree-1;
   for (int i=0;i<=q.degree;
                          i=i+1)
        q.coefs[i]=
              (i+1)*coefs[i+1];
   return q;
}
```

newraph.cpp

```
int main()
{
  poly p,q;

  p.ReadIn();
  q=p.diff();
  cin >> x >> tol;
  fval=p.eval(x);
  while ((fabs(fval)>tol)
              && (count<1000))
  {
     der=q.eval(x);
     x=x-fval/der;
     count=count+1;
     fval=p.eval(x);

  };
  cout << ...
}
```

Whats happening?

- The polynomial p is read in.
- The initial guess value x and *tol* is next read.
- Notice how q, the derivative of p is craeted.

newraph.cpp

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```

Whats happening?

- The polynomial p is read in.
- The initial guess value x and tol is next read.
- Notice how q, the derivative of p is craeted.
- Next the loop is set-up and the iterations begin.
- Notice how q is evaluated
- finally, outputs are generated.

Whats the big deal?

```
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-1 0 1
-1.5 0.0000000001
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Thus $p = x^2 - 1$, the initial gues is -1.5 and the tolerance is 10^{-10}!

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iterations 4
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Just 4 iterations.

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```
[sohoni@nsl-13]$ ./a.out <input
final root -1
iterations 5
```

5 iterations.

Assignment

- Write a function on poly to evaluate the k-th derivative at the point x.
- Use this function to write p.multiplyby(q) which multiplies polynomial p by q (and stores it in p).
- Now write p.DivideBy(q) and implement polynomial long division.