

# STAT 598W Homework 4

Due by April 6, 2016

## 1 Matrix Class

Complete the following matrix class. There are several member functions in the derived class that are optional, though I suggest that you give them a try. All the required functions can be based on Gaussian Elimination and you do not need to consider numerical errors. Simply run the most basic algorithm is enough for this assignment.

```
template<class T, int m, int n>
class Matrix {
    vector<vector<T>> elements;
    int nrow;
    int ncol;
public:
    Matrix();
    Matrix(Matrix<T, m, n>&);

    T& operator() (int, int); //get elements in the matrix
    vector<T> row(int); //get ith row as a vector
    vector<T> col(int); //get jth columne as a vector

    //need to overload +, - and *
    //For *, consider both scalar and matrix multiplication

    Matrix<T, n, m> transpose(); //return the transpose of the matrix
    Matrix<T, m, n> GaussElimination(); //return the Gauss elimination
    int rank(); //return the rank of the matrix
    vector<vector<T>> Solve(const vector<T>&);
    //solve a linear equation Ax = b,
    //where A is the matrix and b is the input parameter.
    //The return value is a base of all solutions.

};

template<class T, int n>
class SquareMatrix :public Matrix<T, n, n> {
public:
    SquareMatrix();
    SquareMatrix(SquareMatrix<T, n>&);

    bool isNonSingular(); //return if the matrix is singular
    SquareMatrix<T, n> inverse(); //return the inverse of the matrix
};
```

```

SquareMatrix<T, n> pow(int n); //calculate A^n

vector<T> Eigenvalue();
//(optional) return all the eigenvalues, in descending order
vector<vector<T>> Eigenvector(T);
//(optional) return the basis of eigenvectors of a certain eigenvalue

SquareMatrix<T, n> cholesky(); //(optional) return the Cholesky decomposition

SquareMatrix<T, n> Q(); //(optional) return the Q of QR decomposition
SquareMatrix<T, n> R(); //(optional) return the R of QR decomposition
};

```

## 2 Stack

Complete the following stack class if you did not complete it in Homework 3.

```

template<class T>
struct stack_node {
    stack_node* next;
    T val;
    stack_node(stack_node* _next) : next(_next) {}
};

template<class T>
class stack {
    typedef stack_node<T> node;
    typedef stack_node<T>* iterator;
    typedef stack_node<T>& reference;
    //Some type define.

    iterator first;
    iterator last;
    size_t length;
    //Three variables we keep.

public:
    stack();
    //Constructor with no parameter.
    stack(T);
    stack(node);
    //Constructor with one node as parameter.
    stack(stack &);
    //Copy constructor.
    ~stack();
    //Destructor.

    size_t size();
    bool empty();
    //Return the size of the list and whether it is empty.

    T& top();
    void push(const T&);
    void pop();

```

```

        //Get the top element, push new element to the top
        //and remove the top element.
};

```

### 3 Queue

Complete the following queue class if you did not complete it in Homework 3.

```

template<class T>
struct queue_node {
    queue_node* next;
    T val;
    queue_node(queue_node* _next) : next(_next) {}
};
template<class T>
class queue {
    typedef queue_node<T> node;
    typedef queue_node<T>* iterator;
    typedef queue_node<T>& reference;
    //Some type define.

    iterator first;
    iterator last;
    size_t length;
    //Three variables we keep.
public:
    queue();
    //Constructor with no parameter.
    queue(T);
    queue(node);
    //Constructor with one node as parameter.
    queue(queue &);
    //Copy constructor.
    ~queue();
    //Destructor.

    size_t size();
    bool empty();
    //Return the size of the list and whether it is empty.

    T& front();
    T& back();
    //Get the next and last element.

    void push(const T&);
    void pop();
    //Push new element to the queue.
    //Remove the next element.
};

```

## 4 Simple Portfolio

In this exercise, we try to construct a class of a simple dynamic portfolio, which consists of stocks and options. Design of the portfolio is up to you, but you should include the following features.

- a. A class for stock. The class should include: (1) a static variable for current time; (2) get the current time, as an integer that starts from zero; (3) update the current time by one unit; (4) get the current stock price; (5) update the current stock price to the next time according to the Black-Scholes model:  $S_{t+1} = S_t \exp(\mu - \frac{1}{2}\sigma^2 + \sigma Z)$ . Of course,  $\mu$  and  $\sigma$  should be variables of the class.
- b. The pool of stocks, which includes all the available stocks in the market.
- c. A class for option. The class should have at least the following features: (1) a static variable for current time and interest rate; (2) variables for maturity time, strike price and whether the option is call or put; (3) a pointer to a stock object as the underlying asset; (4) a public method that returns the current option price, keeping in mind that after maturity, the price of the option simply changes by the interest rate; (5) a public method that updates the option price to the current time.
- d. A class for portfolio. The class should contain several stocks and several options. Some important features should include: (1) for each type of asset, either option or stock, keep track of the number of shares held in the portfolio, keeping in mind that we might short sell; (2) keep track of the total value of the portfolio; (3) change position (by overloading operator + and -) for a certain asset, keeping in mind that this may include going long or going short, and also that it is possible to either add a new asset, or add to an existing asset, or remove completely an existing asset; (4) combine two portfolio (by overloading operator +); (5) update the time and meanwhile update the all the prices in the portfolio.