Sparse Matrices

June 20, 2017

Student: Preda Iulian Octavian

Computer Programming: Programming Techniques(English Language)

Group CEN1.2 B

1st Year

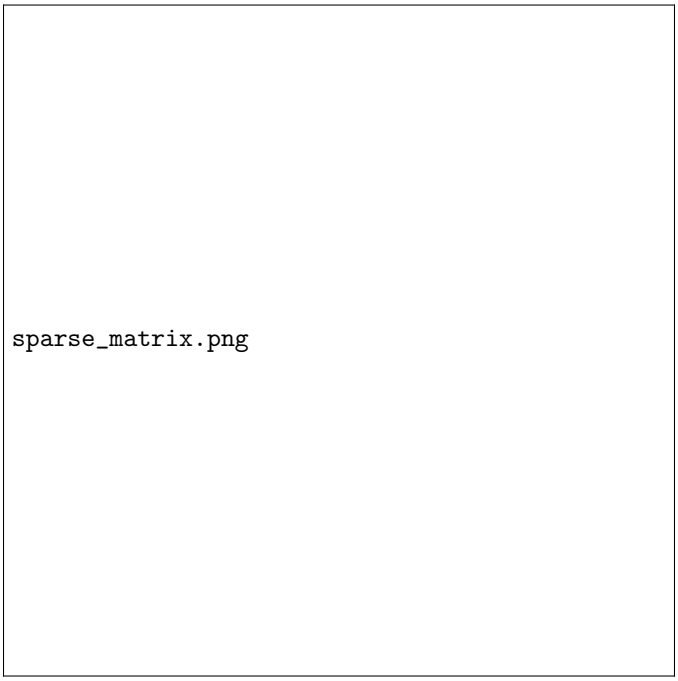
Introduction

In numerical analysis and computer science, a sparse matrix or sparse array is a matrix in which most of the elements are zero.Large sparse matrices often appear in scientific or engineering applications when solving partial differential equations.

When storing and manipulating sparse matrices on a computer, it is beneficial and often necessary to use specialized algorithms and data structures that take advantage of the sparse structure of the matrix. Operations using standard dense-matrix structures and algorithms are slow and inefficient when applied to large sparse matrices as processing and memory are wasted on the zeroes. Sparse data is by nature more easily compressed and thus require significantly less storage. Some very large sparse matrices are hard to manipulate using standard dense-matrix algorithms.

Problem statement

Create a library for operations with sparse matrices. The library should provide at least addition and multiplication.



Pseudocode

For each operation required a function has been designed.
Here are the important functions:

```
int readMatrix(int mat[1001000][3], int noRows, int noCols){
    printf("Insert the elements of the matrix:\n");
    int row,col,len=0;
    for( row = 1; row <= noRows; row ++){
        for( col = 1; col<= noCols; col ++){

            int e;
            scanf("%d",&e);
            if( e != 0){
                len ++;
                mat[len][0] = row;
                mat[len][1] = col;
                mat[len][2] = e;
            }
        }
    }
    mat[len+1][0] = noRows + 1;
    mat[len+1][1] = noRows + 1;
    return len;
}
```

```
int add(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3],
     int resMat[1001000][3]){
    if( noRows1 != noRows2 || noCols1 != noCols2 ){
        printf("Sorry, but you cannot add the matrices as they do not
             have the same sizes");
        isAdded = 0;
        return 0;
    }
    else{
        resLen = len1 + len2;
        int it1, it2; //the iterators for the matrices
        it1 = it2 = 1;
        while(it1 <= len1 || it2 <= len2){
            if(mat1[it1][0] < mat2[it2][0])
                it1 ++;
            else if(mat1[it1][0] > mat2[it2][0])
                it2 ++;
            else{
                if(mat1[it1][1] < mat2[it2][1])
                    it1 ++;
                else if(mat1[it1][1] > mat2[it2][1])
                    it2 ++;
```

```
        else{
            if(mat1[it1][2] + mat2[it2][2] == 0)
                resLen -= 2;
            else
                resLen --;
            it1 ++;
            it2 ++;
        }
    }
}
it1 = it2 = 1;
int resIt = 1;
while(it1 <= len1 || it2 <= len2){
    if(mat1[it1][0] < mat2[it2][0]){
        resMat[resIt][0] = mat1[it1][0];
        resMat[resIt][1] = mat1[it1][1];
        resMat[resIt][2] = mat1[it1][2];
        it1 ++;
        resIt ++;
    }
    else if(mat1[it1][0] > mat2[it2][0]){
        resMat[resIt][0] = mat2[it2][0];
        resMat[resIt][1] = mat2[it2][1];
        resMat[resIt][2] = mat2[it2][2];
        it2 ++;
        resIt ++;
    }
    else{
        if(mat1[it1][1] < mat2[it2][1]){
            resMat[resIt][0] = mat1[it1][0];
            resMat[resIt][1] = mat1[it1][1];
            resMat[resIt][2] = mat1[it1][2];
            it1 ++;
            resIt ++;
        }
        else if(mat1[it1][1] > mat2[it2][1]){
            resMat[resIt][0] = mat2[it2][0];
            resMat[resIt][1] = mat2[it2][1];
            resMat[resIt][2] = mat2[it2][2];
            it2 ++;
            resIt ++;
        }
        else{
            if(mat1[it1][2] + mat2[it2][2] == 0);
            else{
                resMat[resIt][0] = mat1[it1][0];
                resMat[resIt][1] = mat1[it1][1];
                resMat[resIt][2] = mat1[it1][2] + mat2[it2][2];
                resIt ++;
            }
```

```
                it1 ++;
                it2 ++;
            }
        }
    }
    return resLen;
  }
}
```

```
int matMult(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]){
  int row1,row2,col,it1,it2;
  if( noCols1 != noRows2 ){
    printf("Sorry, but you cannot multiply the matrices as they do
        not have corresponding sizes");
    isMulted = 0;
    return 0;
  }
  else{
    for( row1 = 1; row1 <= noRows1; row1 ++){
      for( row2 = 1; row2 <= noRows2; row2 ++){
        int sum = 0;
        for( col = 1; col <= noCols1; col ++){
          for( it1 = 1; it1 <= len1; it1 ++){
            if(row1 == mat1[it1][0] && col == mat1[it1][1]){
              for( it2 = 1; it2 <= len2; it2 ++){
                if(col == mat2[it2][0] && row2 ==
                    mat2[it2][1])
                  sum += mat1[it1][2] * mat2[it2][2];
              }
            }
          }
        }
        if(sum != 0){
          resLen ++;
          resMat[resLen][0] = row1;
          resMat[resLen][1] = row2;
          resMat[resLen][2] = sum;
        }
      }
    }
    return resLen;
  }
}
```

```
void intMult(int len, int mat[1001000][3], int fact){
  int it;
  for( it = 1; it <= len; it ++){
```

```
        mat[it][2] *= fact;
    }
}
```

```
int subtr(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]){
    if (subtr1 == 1){
        intMult(len2, mat2, -1);
        isAdded = 1;
        resLen = add(len1, mat1, len2, mat2, resMat);
        intMult(len2, mat2, -1);
    }else{
        intMult(len1, mat1, -1);
        isAdded = 1;
        resLen = add(len1, mat1, len2, mat2, resMat);
        intMult(len1, mat1, -1);
    }
    return resLen;
}
```

```
void printMat(int mat[1001000][3]){
    int row,col;
        int resIt = 1;
        for( row = 1; row <= noRows1; row ++){
            for( col = 1; col <= noCols1; col ++){
                if( mat[resIt][0] == row && mat[resIt][1] == col ){
                    printf("%d ", mat[resIt][2]);
                    resIt ++;
                }
                else
                    printf("0 ");
            }
            printf("\n");
        }
    }
```

Application Design

The library contains the header functions.h contains the function prototypes to compute the required operations. These are all of them:
−void int readMatrix(int mat[1001000][3], int noRows, int noCols)
−int add(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3], int resMat[1001000][3])
−int matMult(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3], int resMat[1001000][3])
−void intMult(int len, int mat[1001000][3], int fact)
−void int subtr(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3], int resMat[1001000][3])
−void void printMat(int Mat[1001000][3])

I used multiple files for for the source code for the purpose of modularity. Every file contains a function linked to the library functions.h Function readMatrix(int mat[1001000][3], int noRows, int noCols)) includes some steps, like

1. read the number of rows and columns of the curent matrix
2. go through the matrix
3. read the current element e and if it is not 0, we store it

Function add(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3], int resMat[1001000][3] includes some steps, like:

1. check that the 2 matrices have the same size, as otherwise we cannot add them
2. finding the resulting matrix size, as it is the sum of the sizes of the other 2 matrices − number of common elements
3. check if two elements have the same position in the two matices, and ifwe do, we check if their sum if 0 in order to decrease the number of elements by 2(as we need to exclude this element from the resulting matrix)
4. we check if the elements of the original matrices are ont he same row and if not we just add the current element to the result matrix
5. check if they are on the same column
6. if they are located at the same position, we add to the result matrix their sum

Function int matMult(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3], int resMat[1001000][3]) includes some steps, like:

1. check that the 2 matrices have sizes that allow multiplication(i.e. the number of collumns from the first matrix = the number of rown from the second matrix)
2. determine the size of the resulting matrix
3. check if the current element (given by row1 and col) is in the first matrix
4. we add to the current sum the product of the values of the 2 elements
5. we add the current element to the resulting matrix

Function intMult(int len, int mat[1001000][3], int fact) multiplies the value of the current element by a given integer

void int subtr(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3], int resMat[1001000][3]) is used to subtract a matrix form another

void printMat(int Mat[1001000][3]) is used to print to the screen the matrix

The most important file, main.c , has one purpose, to call all the other function in a designed order.
First, the user introduces the two matrices the programe will perform operation on. Then the program sums the matrices up, subrtact them and multiply them.

Source Code

```
//----------------------------functions.h-------------------------------


int noRows1,noCols1,noRows2,noCols2; //the sizes of the 2 matrices
int mat1[1001000][3],mat2[1001000][3]; //the 2 matrices after they are
//compressed into the following pattern: row, column, value
int resMat[1001000][3]; //the resulting matrix
int resLen; //the length of the resulting matrix
int len1,len2; //the lengths of the 2 matrices after compression
int isAdded,isMulted; //to check that matrix add or mult has taken place
int fact; //the integer by which a matrix is multiplied
int subtr1;//the integer used for choosing how to subtract matrices

int readMatrix(int mat[1001000][3], int noRows, int noCols);
int add(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3],
    int resMat[1001000][3]);
int matMult(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]);
void intMult(int len, int mat[1001000][3], int fact);
int subtr(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]);
void printMat(int Mat[1001000][3]);
```

```
//----------------------------readMat.c-------------------------------
#include "functions.h"
int readMatrix(int mat[1001000][3], int noRows, int noCols){
   ///first, we read the number of rows and columns of the current
       matrix
   ///now we go through the matrix
   printf("Insert the elements of the matrix:\n");
   int row,col,len=0;
   for( row = 1; row <= noRows; row ++){
      for( col = 1; col<= noCols; col ++){
         ///we read the current element \var e and if it is not 0, we
             store it
         int e;
         scanf("%d",&e);
         if( e != 0){
            len ++;
            mat[len][0] = row;
            mat[len][1] = col;
            mat[len][2] = e;
         }
      }
   }
   mat[len+1][0] = noRows + 1;
```

```
    mat[len+1][1] = noRows + 1;
    return len;
}

//-----------------------------readMat.c-------------------------------
#include "functions.h"
int add(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3],
    int resMat[1001000][3]){
    ///the first thing we need to do is to check that the 2 matrices
        have the
    ///same size, as otherwise we cannot add them
    if( noRows1 != noRows2 || noCols1 != noCols2 ){
        printf("Sorry, but you cannot add the matrices as they do not
            have the same sizes");
        isAdded = 0;
        return 0;
    }
    ///now we need to calculate the resulting matrix
    ///first we need to know its size, as it is the sum of the sizes of
    ///the other 2 matrices - number of common elements
    else{
        resLen = len1 + len2;
        int it1, it2; //the iterators for the matrices
        it1 = it2 = 1;
        while(it1 <= len1 || it2 <= len2){
            ///first we check if they are on the same row
            if(mat1[it1][0] < mat2[it2][0])
                it1 ++;
            else if(mat1[it1][0] > mat2[it2][0])
                it2 ++;
            else{
                ///now we check if they are on the same column
                if(mat1[it1][1] < mat2[it2][1])
                    it1 ++;
                else if(mat1[it1][1] > mat2[it2][1])
                    it2 ++;
                else{
                    ///we know that we have 2 elements located at the same
                        position
                    ///now we have to check if their sum if 0 in order to
                        decrease
                    ///the number of elements by 2(as we need to exclude
                        this
                    ///element from the new matrix), or not, to decrease
                        it by 1
                    if(mat1[it1][2] + mat2[it2][2] == 0)
                        resLen -= 2;
                    else
                        resLen --;
                    it1 ++;
```

```
            it2 ++;
        }
    }
}
///now we do the addition itself
it1 = it2 = 1;
int resIt = 1; //the iterator tfor the resulting matrix
while(it1 <= len1 || it2 <= len2){
    ///first we check if the elements of the original matrices
        are on
    ///the same row and if not we just add the current element
        to the
    ///result matrix
    if(mat1[it1][0] < mat2[it2][0]){
        resMat[resIt][0] = mat1[it1][0];
        resMat[resIt][1] = mat1[it1][1];
        resMat[resIt][2] = mat1[it1][2];
        it1 ++;
        resIt ++;
    }
    else if(mat1[it1][0] > mat2[it2][0]){
        resMat[resIt][0] = mat2[it2][0];
        resMat[resIt][1] = mat2[it2][1];
        resMat[resIt][2] = mat2[it2][2];
        it2 ++;
        resIt ++;
    }
    else{
        ///now we check if they are on the same column
        if(mat1[it1][1] < mat2[it2][1]){
            resMat[resIt][0] = mat1[it1][0];
            resMat[resIt][1] = mat1[it1][1];
            resMat[resIt][2] = mat1[it1][2];
            it1 ++;
            resIt ++;
        }
        else if(mat1[it1][1] > mat2[it2][1]){
            resMat[resIt][0] = mat2[it2][0];
            resMat[resIt][1] = mat2[it2][1];
            resMat[resIt][2] = mat2[it2][2];
            it2 ++;
            resIt ++;
        }
        else{
            ///as they are located as the same position, we add to
                the
            ///resulting matrix their sum
            if(mat1[it1][2] + mat2[it2][2] == 0);
                ///if it is 0 we do not add anything
            else{
```

```
                    resMat[resIt][0] = mat1[it1][0];
                    resMat[resIt][1] = mat1[it1][1];
                    resMat[resIt][2] = mat1[it1][2] + mat2[it2][2];
                    resIt ++;
                }
                it1 ++;
                it2 ++;
            }
        }
    }
    return resLen;
  }
}


//-----------------------------matMult.c-------------------------------
#include "functions.h"
int matMult(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]){
   ///the first thing we need to do is to check that the 2 matrices have
   ///sizes that allow multiplication(noCols1 = noRows2)
   int row1,row2,col,it1,it2;
   if( noCols1 != noRows2 ){
       printf("Sorry, but you cannot multiply the matrices as they do
           not have corresponding sizes");
       isMulted = 0;
       return 0;
   }
   else{
       ///now we need to determine the size of the resulting matrix
       for( row1 = 1; row1 <= noRows1; row1 ++){
           for( row2 = 1; row2 <= noRows2; row2 ++){
               int sum = 0;
               ///we compute the value of the current element
               for( col = 1; col <= noCols1; col ++){
                   for( it1 = 1; it1 <= len1; it1 ++){
                       ///now we need to check if the current element,
                           given by
                       ///row1 and col is in the first matrix
                       if(row1 == mat1[it1][0] && col == mat1[it1][1]){
                           for( it2 = 1; it2 <= len2; it2 ++){
                               ///now we check if it is in the second
                                   matrix
                               ///given by row2 and col
                               if(col == mat2[it2][0] && row2 ==
                                   mat2[it2][1])
                                   ///we add to the current sum the
                                       product of
                                   ///the values of the 2 elements
                                   sum += mat1[it1][2] * mat2[it2][2];
```

```
                    }
                }
            }
        }
        ///we add 1 to the size of the result matrix if the sum
            is != 0
        if(sum != 0){
            resLen ++;
            resMat[resLen][0] = row1;
            resMat[resLen][1] = row2;
            resMat[resLen][2] = sum;
        }
    }
}



    ///finally, we compute the actual multiplication
    return resLen;
}
}

//-----------------------------scalarMult.c-------------------------------
#include "functions.h"
void intMult(int len, int mat[1001000][3], int fact){
    ///the only thing we need to do here is to multiply the value of the
    ///current element by fact
    int it;
    for( it = 1; it <= len; it ++){
        mat[it][2] *= fact;
    }
}

//-----------------------------subtract.c---------------------------------
#include "functions.h"
int subtr(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]){
    ///this is basically multiplying one matrix with -1 and then adding
        them
    if (subtr1 == 1){
        intMult(len2, mat2, -1);
        isAdded = 1;
        resLen = add(len1, mat1, len2, mat2, resMat);
        intMult(len2, mat2, -1);
    }else{
        intMult(len1, mat1, -1);
        isAdded = 1;
        resLen = add(len1, mat1, len2, mat2, resMat);
        intMult(len1, mat1, -1);
    }
```

```
    return resLen;
}

//------------------------------printMat.c------------------------------
#include "functions.h"
void printMat(int mat[1001000][3]){
    int row,col;
        int resIt = 1;
        for( row = 1; row <= noRows1; row ++){
            for( col = 1; col <= noCols1; col ++){
                if( mat[resIt][0] == row && mat[resIt][1] == col ){
                    printf("%d ", mat[resIt][2]);
                    resIt ++;
                }
                else
                    printf("0 ");
            }
            printf("\n");
        }
    }
```

```
//--------------------------------main.c--------------------------------

//------------------------------readMat.c------------------------------
#include "functions.h"
int readMatrix(int mat[1001000][3], int noRows, int noCols){
    ///first, we read the number of rows and columns of the current
        matrix
    ///now we go through the matrix
    printf("Insert the elements of the matrix:\n");
    int row,col,len=0;
    for( row = 1; row <= noRows; row ++){
        for( col = 1; col<= noCols; col ++){
            ///we read the current element \var e and if it is not 0, we
                store it
            int e;
            scanf("%d",&e);
            if( e != 0){
                len ++;
                mat[len][0] = row;
                mat[len][1] = col;
                mat[len][2] = e;
            }
        }
    }
    mat[len+1][0] = noRows + 1;
    mat[len+1][1] = noRows + 1;
    return len;
}
```

```
//-----------------------------readMat.c-------------------------------
#include "functions.h"
int add(int len1, int mat1[1001000][3], int len2, int mat2[1001000][3],
    int resMat[1001000][3]){
    ///the first thing we need to do is to check that the 2 matrices
        have the
    ///same size, as otherwise we cannot add them
    if( noRows1 != noRows2 || noCols1 != noCols2 ){
        printf("Sorry, but you cannot add the matrices as they do not
            have the same sizes");
        isAdded = 0;
        return 0;
    }
    ///now we need to calculate the resulting matrix
    ///first we need to know its size, as it is the sum of the sizes of
    ///the other 2 matrices - number of common elements
    else{
        resLen = len1 + len2;
        int it1, it2; //the iterators for the matrices
        it1 = it2 = 1;
        while(it1 <= len1 || it2 <= len2){
            ///first we check if they are on the same row
            if(mat1[it1][0] < mat2[it2][0])
                it1 ++;
            else if(mat1[it1][0] > mat2[it2][0])
                it2 ++;
            else{
                ///now we check if they are on the same column
                if(mat1[it1][1] < mat2[it2][1])
                    it1 ++;
                else if(mat1[it1][1] > mat2[it2][1])
                    it2 ++;
                else{
                    ///we know that we have 2 elements located at the same
                        position
                    ///now we have to check if their sum if 0 in order to
                        decrease
                    ///the number of elements by 2(as we need to exclude
                        this
                    ///element from the new matrix), or not, to decrease
                        it by 1
                    if(mat1[it1][2] + mat2[it2][2] == 0)
                        resLen -= 2;
                    else
                        resLen --;
                    it1 ++;
                    it2 ++;
                }
            }
```

```
}
///now we do the addition itself
it1 = it2 = 1;
int resIt = 1; //the iterator tfor the resulting matrix
while(it1 <= len1 || it2 <= len2){
     ///first we check if the elements of the original matrices
         are on
     ///the same row and if not we just add the current element
         to the
     ///result matrix
    if(mat1[it1][0] < mat2[it2][0]){
        resMat[resIt][0] = mat1[it1][0];
        resMat[resIt][1] = mat1[it1][1];
        resMat[resIt][2] = mat1[it1][2];
        it1 ++;
        resIt ++;
    }
    else if(mat1[it1][0] > mat2[it2][0]){
        resMat[resIt][0] = mat2[it2][0];
        resMat[resIt][1] = mat2[it2][1];
        resMat[resIt][2] = mat2[it2][2];
        it2 ++;
        resIt ++;
    }
    else{
        ///now we check if they are on the same column
        if(mat1[it1][1] < mat2[it2][1]){
            resMat[resIt][0] = mat1[it1][0];
            resMat[resIt][1] = mat1[it1][1];
            resMat[resIt][2] = mat1[it1][2];
            it1 ++;
            resIt ++;
        }
        else if(mat1[it1][1] > mat2[it2][1]){
            resMat[resIt][0] = mat2[it2][0];
            resMat[resIt][1] = mat2[it2][1];
            resMat[resIt][2] = mat2[it2][2];
            it2 ++;
            resIt ++;
        }
        else{
            ///as they are located as the same position, we add to
                the
            ///resulting matrix their sum
            if(mat1[it1][2] + mat2[it2][2] == 0);
                ///if it is 0 we do not add anything
            else{
                resMat[resIt][0] = mat1[it1][0];
                resMat[resIt][1] = mat1[it1][1];
                resMat[resIt][2] = mat1[it1][2] + mat2[it2][2];
```

```
                    resIt ++;
                }
                it1 ++;
                it2 ++;
            }
        }
    }
    return resLen;
  }
}


//-----------------------------matMult.c-------------------------------
#include "functions.h"
int matMult(int len1, int mat1[1001000][3], int len2, int
    mat2[1001000][3], int resMat[1001000][3]){
   ///the first thing we need to do is to check that the 2 matrices have
   ///sizes that allow multiplication(noCols1 = noRows2)
   int row1,row2,col,it1,it2;
   if( noCols1 != noRows2 ){
       printf("Sorry, but you cannot multiply the matrices as they do
           not have corresponding sizes");
       isMulted = 0;
       return 0;
   }
   else{
       ///now we need to determine the size of the resulting matrix
       for( row1 = 1; row1 <= noRows1; row1 ++){
           for( row2 = 1; row2 <= noRows2; row2 ++){
               int sum = 0;
               ///we compute the value of the current element
               for( col = 1; col <= noCols1; col ++){
                   for( it1 = 1; it1 <= len1; it1 ++){
                       ///now we need to check if the current element,
                           given by
                       ///row1 and col is in the first matrix
                       if(row1 == mat1[it1][0] && col == mat1[it1][1]){
                           for( it2 = 1; it2 <= len2; it2 ++){
                               ///now we check if it is in the second
                                   matrix
                               ///given by row2 and col
                               if(col == mat2[it2][0] && row2 ==
                                   mat2[it2][1])
                                   ///we add to the current sum the
                                       product of
                                   ///the values of the 2 elements
                                   sum += mat1[it1][2] * mat2[it2][2];
                           }
                       }
                   }
```

```
            }
            ///we add 1 to the size of the result matrix if the sum
                is != 0
            if(sum != 0){
                resLen ++;
                resMat[resLen][0] = row1;
                resMat[resLen][1] = row2;
                resMat[resLen][2] = sum;
            }
        }
    }



    ///finally, we compute the actual multiplication
    return resLen;
  }
}

//-----------------------------scalarMult.c--------------------------------
#include "functions.h"
void intMult(int len, int mat[1001000][3], int fact){
  ///the only thing we need to do here is to multiply the value of the
  ///current element by fact
  int it;
  for( it = 1; it <= len; it ++){
    mat[it][2] *= fact;
  }
}

//-----------------------------subtract.c--------------------------------
#include "functions.h"
int subtr(int len1, int mat1[1001000][3], int len2, int
   mat2[1001000][3], int resMat[1001000][3]){
  ///this is basically multiplying one matrix with -1 and then adding
      them
  if (subtr1 == 1){
    intMult(len2, mat2, -1);
    isAdded = 1;
    resLen = add(len1, mat1, len2, mat2, resMat);
    intMult(len2, mat2, -1);
  }else{
    intMult(len1, mat1, -1);
    isAdded = 1;
    resLen = add(len1, mat1, len2, mat2, resMat);
    intMult(len1, mat1, -1);
  }
  return resLen;
}
```

```c
//----------------------------printMat.c------------------------------
#include "functions.h"
void printMat(int mat[1001000][3]){
    int row,col;
        int resIt = 1;
        for( row = 1; row <= noRows1; row ++){
            for( col = 1; col <= noCols1; col ++){
                if( mat[resIt][0] == row && mat[resIt][1] == col ){
                    printf("%d ", mat[resIt][2]);
                    resIt ++;
                }
                else
                    printf("0 ");
            }
            printf("\n");
        }
    }
```

Experiments and results

1.png	2.png

Conclusions

Working on this project, I have gained a new appreciation for these relatively simple matrices and their many uses in the information world. The appli- cations for sparse matrices are many and varied. They can be used in combinatorics and application areas such as network theory, which have a low density of significant data or connections .Large sparse matrices often appear in scientific or engineering applications when solving partial differential equations.

References

1)www.stackoverflow.com

2)https://en.wikipedia.org/wiki/Sparsematrix

3)http://www.sharelatex.com