云南大学数学与统计学院
上机实践报告

课程名称： 数值计算实验	**年级：** 2015 级	**上机实践成绩：**
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上机实践名称： 线性方程组的直接法	**学号：** 20151910042	**上机实践日期：** 2017-10-16
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一、 实验目的

1. 通过对所学的线性方程组直接求解的理论方法进行编程，提升程序编写水平；
2. 通过对理论方法的编程实验，进一步掌握理论方法的每一个细节；
3. 通过数值法求解，发现数值方法与符号方法的区别，并形成专业思维。

二、 实验内容

1. 编程实现高斯-若尔当列主元消元法；
2. 编程实现高斯-若尔当全主元消元法；
3. 任选一种方案，Doolittle 分解或者 Crout 分解，编程实现矩阵的 LU 分解；
4. 编程实现三对角线矩阵的稀疏方式存储，然后对其进行 LU 分解。

三、 实验平台

Windows 10 1703 Enterprise 中文版；
Python 3.6.0；
Wing IDE Professional 6.0.5-1 集成开发环境；
MATLAB R2017b win64；
AxMath 公式编辑器（辅助）；
EndNote X8 文献管理。

四、 实验记录与实验结果分析

4.1 1 题

编程实现：用高斯-若尔当列主元消元法求下列方程的解[1]：

$$\begin{cases} x_1 + 2x_2 + x_3 = 2 \\ -2x_1 - 2x_2 - x_3 = -3 \\ 2x_1 - 3x_2 - 2x_3 = -1 \end{cases}$$

解答：

4.1.1 程序代码

```
1    # filename: 3.1 ColumnPivotMethod.py
2
```

```
3   class Matrix:
4       """Abatrct class representing a Matrix.
5
6       The internal structure is two dimension list.
7       """
8       def __init__(self,m,n,mainCol):
9           """
10          self.row:           the row of the Matrix
11          self.col:           the collumn of the Matrix
12          self.CheckedRow:     if one row has been checked,
13                              it should not be checked again
14          self.body:          the internal storing structure
15          self.mainCol:       the coefficient matrix
16          """
17          self.row = m
18          self.col = n
19          self.CheckedRow = set(range(self.row))
20          self.body = [[0 for i in range(n)] for i in range(m)]
21          self.mainCol = mainCol
22
23      def getVal(self):
24          """Giving value to each element of the matrix.
25
26          Overwrite the original value zeros.
27          """
28          for i in range(self.row):
29              for j in range(self.col):
30                  self.body[i][j] = int(input())
31
32      def valid(self,e):
33          """If the two matrix are not in the same form, return false,
34          else return true.
35
36          It is useful in the next functions.
37          """
38          if self.row != e.row or self.col != e.col:
39              return False
40          else:
41              return True
42
43      def add(self,e):
44          """A methon does not used in the pivot PCA algorithm.
45
46          Maybe it will be used in other programs.
47          """
48          self.valid(e)
49          tmp = Matrix(self.row,self.col,self.mainCol)
50          for i in range(self.row):   # deep copy
51              for j in range(self.col):
```

```
52                 tmp.body[i][j] = self.body[i][j]
53
54             for i in range(self.row):
55                 for j in range(self.col):
56                     tmp.body[i][j] += e.body[i][j]
57             return tmp
58
59         def constMulti(self,const):
60             """A constant number multiple a matrix."""
61             tmp = Matrix(self.row,self.col,self.mainCol)
62             for i in range(self.row):   # deep copy
63                 for j in range(self.col):
64                     tmp.body[i][j] = self.body[i][j]
65
66             for i in range(self.row):
67                 for j in range(self.col):
68                     tmp.body[i][j] *= const
69             return tmp
70
71         def matrixTransform(self,target_row_Number,source_row_Number,times=None):
72             """There is a big problem, every decimal number we see is stored in the
73             RAM with the binary platform.
74
75             I can import the decimal lib to solve this problem, but I did not!
76             """
77             if times == None:    # special case of matrixTransform(TarRow,times)
78
79                 times_tmp = source_row_Number
80                 for j in range(self.col):
81                     self.body[target_row_Number][j] *= times_tmp
82                 return
83             elif times == 'exchange':
84                 for i in range(self.col):
85                     self.body[target_row_Number][i],\
86                         self.body[source_row_Number][i] \
87                         = self.body[source_row_Number][i],\
88                         self.body[target_row_Number][i]
89                 return
90             else:
91                 for i in range(self.col):
92                     self.body[target_row_Number][i] += \
93                     times * self.body[source_row_Number][i]
94
95         def Peel(self,layer):
96             """Getting part of the matrix."""
97             B = Matrix(self.row-layer,self.col-layer,self.mainCol)
98             for i in range(self.row-layer):
99                 for j in range(self.col-layer):
100                    B.body[i][j] = A.body[i + layer][j + layer]
```

```
101         return B
102 
103     def combine(self,B,layer):
104         """A long with method Peel."""
105         for i in range(self.row-layer):
106             for j in range(self.col-layer):
107                 A.body[i + layer][j + layer] = B.body[i][j]
108 
109 def GaussJordanCol_col(A):
110     Max = 0                        # initialize the variable
111     position = 0                    # the row number of the maximum value
112     for i in range(min(A.row,A.mainCol)):
113 
114         for j in A.CheckedRow:      # getting the max and position by a flow
115             if abs(Max) <= abs(A.body[j][i]):
116                 Max = A.body[j][i]
117                 position = j
118 
119         A.CheckedRow.remove(position)   # this row should not be checked again
120 
121         A.matrixTransform(position, 1 / Max)
122 
123         for j in range(A.row):
124             if j != position:
125                 A.matrixTransform(j,position,-1 * A.body[j][i])
126 
127         Max = 0          # reinitialize the variables
128         position = 0
129 
130     begin = 0
131     for j in range(A.mainCol):
132         for i in range(A.row):
133             if A.body[i][j] == 1:
134                 A.matrixTransform(begin,i,'exchange')
135                 begin += 1
136     return A
137 
138 """-------------------------my Main Function-------------------------"""
139 
140 A = Matrix(3,6,3)
141 A.body[0] = [1,2,3,1,0,0]
142 A.body[1] = [2,4,5,0,1,0]
143 A.body[2] = [3,5,6,0,0,1]
144 
145 print('The original matrix is shown below:\n')
146 for i in range(A.row):
147     for j in range(A.col):
148         print(int(A.body[i][j]),'\t',end='')
149     print('')
```

```
150
151 A = GaussJordanCol_col(A)
152
153 print('\nThe matrix after primary transformation is shown below:\n')
154 for i in range(A.row):
155     for j in range(A.col):
156         if A.body[i][j] == 0.0:
157             A.body[i][j] = 0
158         if A.body[i][j] == -0.0:
159             A.body[i][j] = 0
160         if A.body[i][j] - round(A.body[i][j]) == 0:
161             A.body[i][j] = round(A.body[i][j])
162         print(round(A.body[i][j],4),'\t',end='')
163     print('')
```

Code Box 1 列主元消元法求线性方程组的解

4.1.2 输出结果

```
ColumnPivotMethod.| Debug I/O (stdin, stdout, stderr) appears below
The original matrix is shown below:

1       2       1       2
-2      -2      -1      -3
2       -3      -2      -1

The matrix after primary transformation is shown below:

1       0       0       1.0
0       1       0       -1.0
0       0       1       3.0
```

输出结果 1

4.1.3 代码分析

本 Python 代码采用面向对象[2]的方式写成，首先是定义了一个 Matrix 类，用来存储矩阵，该类中的所有元素都是 public 的，这样设置是为了以后的编程调用方便。

Matrix 的实例 A 是一个三行四列的矩阵，其中最后一列是方程组中等号右边的元素，所以这个增广矩阵的计算应该遵循线性代数的法则，即在寻找列主元的时候，不能越界去增广列寻找；同样，一个已经找出过列主元的行，不应该再次存在列主元，所以要在以后的查找中剔除这一行。

最后，输出的结果应该保持美观性，所以按照系数矩阵经过变换之后为单位矩阵的样式进行了重新排序。

值得指出的是，Matrix 的 matrixTransform 成员函数是用多态的方式写的，可以满足行数乘、行交换、

行倍加等所有的矩阵初等变换方式。

另外，由于本线性方程组一定存在唯一解，所以在排序与寻找主元的过程中，并没有加以判断，所以这并不是一个通用的程序。

4.2 2 题

编程实现：请用高斯-若尔当全主元消元法求下列矩阵的逆矩阵[1]：

$$\mathrm{B}=\begin{bmatrix} 2 & 1 & -3 & -1 \\ 3 & 1 & 0 & 7 \\ -1 & 2 & 4 & -2 \\ 1 & 0 & -1 & 5 \end{bmatrix}$$

4.2.1 程序代码

```
# filename: 3.2 CompletePivotMethod.py

class Matrix:
    """Abatrct class representing a Matrix.

    The internal structure is two dimension list.
    """
    def __init__(self,m,n,mainCol):
        """
        self.row:           the row of the Matrix
        self.col:           the collumn of the Matrix
        self.CheckedRow:     if one row has been checked,
                            it should not be checked again
        self.body:          the internal storing structure
        self.mainCol:       the coefficient matrix
        """
        self.row = m
        self.col = n
        self.CheckedRow = set(range(self.row))
        self.body = [[0 for i in range(n)] for i in range(m)]
        self.mainCol = mainCol

    def getVal(self):
        """Giving value to each element of the matrix.

        Overwrite the original value zeros.
        """
        for i in range(self.row):
            for j in range(self.col):
                self.body[i][j] = int(input())

    def valid(self,e):
        """If the two matrix are not in the same form, return false,
        else return true.

```

```
36          It is useful in the next functions.
37          """
38          if self.row != e.row or self.col != e.col:
39              return False
40          else:
41              return True
42
43      def add(self,e):
44          """A methon does not used in the pivot PCA algorithm.
45
46          Maybe it will be used in other programs.
47          """
48          self.valid(e)
49          tmp = Matrix(self.row,self.col,self.mainCol)
50          for i in range(self.row):   # deep copy
51              for j in range(self.col):
52                  tmp.body[i][j] = self.body[i][j]
53
54          for i in range(self.row):
55              for j in range(self.col):
56                  tmp.body[i][j] += e.body[i][j]
57          return tmp
58
59      def constMulti(self,const):
60          """A constant number multiple a matrix."""
61          tmp = Matrix(self.row,self.col,self.mainCol)
62          for i in range(self.row):   # deep copy
63              for j in range(self.col):
64                  tmp.body[i][j] = self.body[i][j]
65
66          for i in range(self.row):
67              for j in range(self.col):
68                  tmp.body[i][j] *= const
69          return tmp
70
71      def matrixTransform(self,target_row_Number,source_row_Number,times=None):
72          """There is a big problem, every decimal number we see is stored in the
73          RAM with the binary platform.
74
75          I can import the decimal lib to solve this problem, but I did not!
76          """
77          if times == None:    # special case of matrixTransform(TarRow,times)
78
79              times_tmp = source_row_Number
80              for j in range(self.col):
81                  self.body[target_row_Number][j] *= times_tmp
82              return
83          elif times == 'exchange':
84              for i in range(self.col):
```

```
85                  self.body[target_row_Number][i],\
86                      self.body[source_row_Number][i] \
87                      = self.body[source_row_Number][i],\
88                      self.body[target_row_Number][i]
89              return
90          else:
91              for i in range(self.col):
92                  self.body[target_row_Number][i] += \
93                  times * self.body[source_row_Number][i]
94
95      def Peel(self,layer):
96          """Getting part of the matrix."""
97          B = Matrix(self.row-layer,self.col-layer,self.mainCol)
98          for i in range(self.row-layer):
99              for j in range(self.col-layer):
100                 B.body[i][j] = A.body[i + layer][j + layer]
101         return B
102
103     def combine(self,B,layer):
104         """A long with method Peel."""
105         for i in range(self.row-layer):
106             for j in range(self.col-layer):
107                 A.body[i + layer][j + layer] = B.body[i][j]
108
109 def GaussJordanCol_complete(A):
110     Max = 0                         # initialize the variable
111     position_row = 0                # the row number of the maximum value
112     position_col = 0
113
114     for i in range(A.row):
115
116         for j in A.CheckedRow:
117             for k in range(A.mainCol):  # not in all the columns
118                 if abs(Max) <= abs(A.body[j][k]):
119                     Max = A.body[j][k]
120                     position_row = j
121                     position_col = k
122
123         A.matrixTransform(position_row, 1 / Max)
124
125         A.CheckedRow.remove(position_row)
126
127         for j in range(A.row):
128             if j != position_row:
129                 A.matrixTransform(j,position_row,-1 * A.body[j][position_col])
130
131         Max = 0
132         position_row = 0
133         position_col = 0
```

```
134
135     begin = 0
136     for j in range(A.mainCol):
137         for i in range(A.row):
138             if A.body[i][j] == 1:
139                 A.matrixTransform(begin,i,'exchange')
140                 begin += 1
141     return A
142
143 """-------------------------my Main Function-------------------------"""
144
145 A = Matrix(4,8,4)
146 A.body[0] = [2,1,-3,1,1,0,0,0]
147 A.body[1] = [3,1,0,7,0,1,0,0]
148 A.body[2] = [-1,2,4,-2,0,0,1,0]
149 A.body[3] = [1,0,-1,5,0,0,0,1]
150
151 print('The original matrix is shown below:\n')
152 for i in range(A.row):
153     for j in range(A.col):
154         print(int(A.body[i][j]),'\t',end='')
155     print('')
156
157 A = GaussJordanCol_complete(A)
158
159 print('\nThe matrix after primary transformation is shown below:\n')
160 for i in range(4):
161     for j in range(8):
162         if A.body[i][j] == 0.0:
163             A.body[i][j] = 0
164         if A.body[i][j] == -0.0:
165             A.body[i][j] = 0
166         if A.body[i][j] - round(A.body[i][j]) == 0:
167             A.body[i][j] = round(A.body[i][j])
168         print(round(A.body[i][j],4),'   ',end='')
169     print('')
```

Code Box 2 全主元消元法求矩阵的逆

4.2.2 输出结果

```
CompletePivotMetho ▾  Debug I/O (stdin, stdout, stderr) appears below
The original matrix is shown below:

2       1       -3      1       1       0       0       0
3       1       0       7       0       1       0       0
-1      2       4       -2      0       0       1       0
1       0       -1      5       0       0       0       1

The matrix after primary transformation is shown below:

1    0    0    0    -0.0506    0.5823    -0.2658    -0.9114
0    1    0    0    0.4177    -0.3038    0.443    0.519
0    0    1    0    -0.2405    0.2658    -0.0127    -0.3291
0    0    0    1    -0.038    -0.0633    0.0506    0.3165
```

输出结果 2

4.2.3 代码分析

此段代码是在 Code Box 1 的基础上略微修改而得的，由于全主元的位置没有固定性，所以要把每一次找到的全主元的行列坐标都存储下来。其余部分与 Code Box 1 相同。

4.3 3 题

编程实现：利用 LU 分解法（Doolittle），求$[x_1, x_2, x_3, x_4]^T$的数值解。

$$\begin{bmatrix} 12 & -3 & 3 & 4 \\ -18 & 3 & -1 & -1 \\ 1 & 1 & 1 & 1 \\ 3 & 1 & -1 & 1 \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} 15 \\ -15 \\ 6 \\ 2 \end{bmatrix}$$

4.3.1 程序代码

```python
# filename: 3.3 LU Decomposition.py

class Matrix:
    """Abatrct class representing a Matrix.

    The internal structure is two dimension list.
    """
    def __init__(self,m,n,mainCol):
        """
        self.row:           the row of the Matrix
        self.col:           the collumn of the Matrix
        self.CheckedRow:     if one row has been checked,
                            it should not be checked again
        self.body:          the internal storing structure
        self.mainCol:       the coefficient matrix
        """
        self.row = m
        self.col = n
        self.CheckedRow = set(range(self.row))
```

```
20          self.body = [[0 for i in range(n)] for i in range(m)]
21          self.mainCol = mainCol
22
23      def getVal(self):
24          """Giving value to each element of the matrix.
25
26          Overwrite the original value zeros.
27          """
28          for i in range(self.row):
29              for j in range(self.col):
30                  self.body[i][j] = int(input())
31
32      def valid(self,e):
33          """If the two matrix are not in the same form, return false,
34          else return true.
35
36          It is useful in the next functions.
37          """
38          if self.row != e.row or self.col != e.col:
39              return False
40          else:
41              return True
42
43      def add(self,e):
44          """A methon does not used in the pivot PCA algorithm.
45
46          Maybe it will be used in other programs.
47          """
48          self.valid(e)
49          tmp = Matrix(self.row,self.col,self.mainCol)
50          for i in range(self.row):   # deep copy
51              for j in range(self.col):
52                  tmp.body[i][j] = self.body[i][j]
53
54          for i in range(self.row):
55              for j in range(self.col):
56                  tmp.body[i][j] += e.body[i][j]
57          return tmp
58
59      def constMulti(self,const):
60          """A constant number multiple a matrix."""
61          tmp = Matrix(self.row,self.col,self.mainCol)
62          for i in range(self.row):   # deep copy
63              for j in range(self.col):
64                  tmp.body[i][j] = self.body[i][j]
65
66          for i in range(self.row):
67              for j in range(self.col):
68                  tmp.body[i][j] *= const
```

```
69          return tmp
70
71      def matrixTransform(self,target_row_Number,source_row_Number,times=None):
72          """There is a big problem, every decimal number we see is stored in the
73          RAM with the binary platform.
74
75          I can import the decimal lib to solve this problem, but I did not!
76          """
77          if times == None:    # special case of matrixTransform(TarRow,times)
78
79              times_tmp = source_row_Number
80              for j in range(self.col):
81                  self.body[target_row_Number][j] *= times_tmp
82              return
83          elif times == 'exchange':
84              for i in range(self.col):
85                  self.body[target_row_Number][i],\
86                      self.body[source_row_Number][i] \
87                      = self.body[source_row_Number][i],\
88                      self.body[target_row_Number][i]
89              return
90          else:
91              for i in range(self.col):
92                  self.body[target_row_Number][i] += \
93                  times * self.body[source_row_Number][i]
94
95      def Peel(self,layer):
96          """Getting part of the matrix."""
97          B = Matrix(self.row-layer,self.col-layer,self.mainCol)
98          for i in range(self.row-layer):
99              for j in range(self.col-layer):
100                 B.body[i][j] = A.body[i + layer][j + layer]
101         return B
102
103     def combine(self,B,layer):
104         """A long with method Peel."""
105         for i in range(self.row-layer):
106             for j in range(self.col-layer):
107                 A.body[i + layer][j + layer] = B.body[i][j]
108
109 def LU_Decompose_Doolittle(A):
110     """Decompose matrix A with Dolittle method.
111
112     In this function, I use devide and conquer method.
113     """
114     for i in range(A.col-1):
115         if i == 0:
116             for j in range(1,A.row):
117                 A.body[j][i] = A.body[j][i] / A.body[0][0]
```

```
        else:
            for j in range(A.col-i):
                for k in range(i):
                    A.body[i][i+j] = A.body[i][i+j] - \
                        A.body[i][k] * A.body[k][i+j]
            for j in range(A.row-i-1):
                for k in range(i):
                    A.body[i+j+1][i] = A.body[i+j+1][i] - \
                        A.body[i+j+1][k] * A.body[k][i]
                A.body[i+j+1][i] = A.body[i+j+1][i] / A.body[i][i]
    return A

"""------------------------my Main Function------------------------"""

A = Matrix(4,5,4)
A.body[0] = [12,-3,3,4,15]
A.body[1] = [-18,3,-1,-1,-15]
A.body[2] = [1,1,1,1,6]
A.body[3] = [3,1,-1,1,2]

print('The original matrix is shown below:\n')
for i in range(A.row):
    for j in range(A.col):
        print(int(A.body[i][j]),'\t',end='')
    print('')

A = LU_Decompose_Doolittle(A)

B = Matrix(4,4,4)
for i in range(A.row):
    for j in range(A.row):
        B.body[i][j] = A.body[i][j]

L1 = Matrix(4,4,4)

for i in range(L1.col):
    for j in range(L1.row-i):
        L1.body[j+i][i] = B.body[j+i][i]
for i in range(L1.row):
    L1.body[i][i] = 1

U = L1.constMulti(-1).add(B)    # I am the best! professional!
for i in range(L1.row):
    U.body[i][i] += 1

print('-----------------------------------\nA:\n')
for i in range(4):
    for j in range(4):
        if B.body[i][j] == 0.0:
```

```
            B.body[i][j] = 0
        if B.body[i][j] == -0.0:
            B.body[i][j] = 0
        if B.body[i][j] - round(B.body[i][j]) == 0:
            B.body[i][j] = round(B.body[i][j])
        print(round(B.body[i][j],2),'\t',end='')
    print('')

print('-----------------------------------\nU:\n')

for i in range(4):
    for j in range(4):
        if U.body[i][j] == 0.0:
            U.body[i][j] = 0
        if U.body[i][j] == -0.0:
            A.body[i][j] = 0
        if U.body[i][j] - round(U.body[i][j]) == 0:
            U.body[i][j] = round(U.body[i][j])
        print(round(U.body[i][j],2),'\t',end='')
    print('')

print('-----------------------------------\nL:\n')

for i in range(4):
    for j in range(4):
        if L1.body[i][j] == 0.0:
            L1.body[i][j] = 0
        if L1.body[i][j] == -0.0:
            L1.body[i][j] = 0
        if L1.body[i][j] - round(L1.body[i][j]) == 0:
            L1.body[i][j] = round(L1.body[i][j])
        print(round(L1.body[i][j],2),'\t',end='')
    print('')
```

Code Box 3 LU 分解

4.3.2 输出结果

```
3.3 LU Decomposition.py (pid 17808) (no process) - Debug process terminated
The original matrix is shown below:

12      -3      3       4       15
-18     3       -1      -1      -15
1       1       1       1       6
3       1       -1      1       2
-----------------------------------
A:

12      -3      3       4
-1.5    -1.5    3.5     5
0.08    -0.83   3.67    4.83
0.25    -1.17   0.64    2.76
-----------------------------------
U:

12      -3      3       4
0       -1.5    3.5     5
0       0       3.67    4.83
0       0       0       2.76
-----------------------------------
L:

1       0       0       0
-1.5    1       0       0
0.08    -0.83   1       0
0.25    -1.17   0.64    1
```

输出结果 3

通过生成的 LU 矩阵，可以轻易得到，$[x_1,\ x_2,\ x_3,\ x_4]^{\mathrm{T}}$的数值解为$[1,\ 2,\ 3,\ 0]$，这也是解析解。

4.3.3 代码分析

代码仍旧是基于面向对象技术，程序的算法是基于紧凑法求解 LU 矩阵的形式化做法。

如此编程，相对而言比较节约内存。

4.4 4 题

编程实现：用追赶法解下列严格对角优势的三对角线方程组，要求用稀疏格式存储矩阵，主内存占用为$O(n)$，其中n为矩阵的行数。

$$\begin{bmatrix} 4 & -1 & & & \\ -1 & 4 & -1 & & \\ & -1 & 4 & -1 & \\ & & -1 & 4 & -1 \\ & & & -1 & 4 \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} 100 \\ 200 \\ 200 \\ 200 \\ 100 \end{bmatrix}$$

4.4.1 程序代码

```
1   # filename: 3.4 Seize Method.py
```

```
2
3   class ThreeTriangleMatrix:
4       def __init__(self,a,b,c,m):
5           self.a = a
6           self.b = b
7           self.c = c
8           self.row = m
9           self.col = m
10
11      def calculate(self):
12          alpha = []
13          beta = []
14          gamma = self.a
15
16          alpha.append(self.b)
17          beta.append(self.c / alpha[0])
18
19          for i in range(1,self.row-1):
20              alpha.append(self.b - gamma * beta[i-1])
21              beta.append(self.c / alpha[i])
22
23          alpha.append(self.b - gamma * beta[-1])
24
25          return [gamma,alpha,beta]
26
27  A = ThreeTriangleMatrix(-1,4,-1,5)
28  A.calculate()
29
30  L = [[0 for i in range(A.row)] for j in range(A.col)]
31
32  for i in range(A.row-1):
33      L[i+1][i] = A.calculate()[0]
34      L[i][i] = A.calculate()[1][i]
35
36  L[A.row-1][A.row-1] = (A.calculate()[1])[A.row-1]
37
38  U1 = [[0 for i in range(A.row)] for j in range(A.col)]
39  for i in range(A.row):
40      U1[i][i] = 1
41
42  for i in range(A.row-1):
43      U1[i][i+1] = A.calculate()[2][i]
44
45  print('----------------------------------\nU1:\n')
46  for i in range(A.row):
47      for j in range(A.col):
48          print(round(U1[i][j],2),'\t',end='')
49      print ('')
50
```

```
print('---------------------------------\nL:]\n')
for i in range(A.row):
    for j in range(A.col):
        print(round(L[i][j],2),'\t',end='')
    print('')
```

Code Box 4 追赶公式求三对角线矩阵的 LU 分解

4.4.2 输出结果

```
3.4 Seize Method.py (pid 16484) (no process)    Debug I/O (stdin, stdout, stderr) appears below
---------------------------------
U1:

1       -0.25   0       0       0
0       1       -0.27   0       0
0       0       1       -0.27   0
0       0       0       1       -0.27
0       0       0       0       1
---------------------------------
L:]

4       0       0       0       0
-1      3.75    0       0       0
0       -1      3.73    0       0
0       0       -1      3.73    0
0       0       0       -1      3.73
```

输出结果 4

做得了 LU 分解，将数据导入 MATLAB，可以迅速求出 $[x_1, x_2, x_3, x_4, x_5]^{\mathrm{T}}$ 的数值解为 $[46.15, 84.61, 92.30, 84.61, 46.15]^{\mathrm{T}}$

4.4.3 代码分析

此程序机械化比较高，所以比较简单，就是简单地翻译数学语言。

五、 实验体会

在此次实验中，集中利用了 MATLAB 与 Python 3 进行程序设计。

主程序是采用 Python 3 进行编写，验算求解是利用 MATLAB 进行。当写的程序足够多之后，就会发现，真正重要的东西是数学思维，编程完全决定于数学思维的深度。如果一味追求编程的快感，很容易在这虚无的成就感中迷失自己。所以编程不如不编，能透彻理解数学思维已经很不容易了。

但是从另一个角度看，编程对数学思维又有很强的检验作用，尽管在数学思维之外，高技巧度编程又是另外广阔的一片天地。通过适度的编程，选择一类题目的典型例子进行编程，就可以在一个程序的设计、实现时间里，考验自己的一批数学思维的掌握牢固程度。

MATLAB 的强大之处不在于它编程方便，而是两方面：友好的交互式控制台，众多高质量的程序包。正是这两点，使得 MATLAB 在工业中得到广泛的应用。但是在数值计算的学习上，利用 Python 或许是更好的选择。Python 的数值计算依赖于数组，所以对于循环的考验非常高。Python 不像 MATLAB 的基本运算都是基于矩阵那样地方便，而正是这不方便这一点，使得 Python 这个看起来更加拙劣的工具更适合新手。

除了工具，更重要的一点是编程。这四个程序的编写基本上没有遇到困难。如果说在理论方面已经理解得足够透彻，那么在编程上不应该存在任何思路困难。数值计算以及数学建模中的程序，很大程度上都是数学语言的直接翻译。这一点与 DSA 设计有相当大的差别。现在出现的一个问题是，编程趋向 IDD 模式，即 IDE Driven，没有了编译器就不会单步调试，进而很难发现哪里出了差错。这不能说是思路理解得不到位，因为如果单纯是这个原因，那么在纸上演算就会遇到问题。但是很显然不是这样。以后的一个突破，可能就在这里——直接用文本编辑器进行代码书写，然后用 IDE 进行检验。

最后需要说明，因为有很多东西没有或者不能调用，所以这四个程序基本上是为题目量身定做。虽然面向对象设计里的几个成员函数具有通用性，但是总得来看，一些全局函数还是缺乏相应的判断。当然，如果不能运行，就从侧面说明输入的矩阵不合格。所以，这四个程序的通用性有待进一步挖掘，数据与程序能彻底分开，是判断程序通用性强弱的主要依据之一。

六、 参考文献

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