MS4303 Matlab Project

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April 12, 2019

1 Introduction

This report contains this Introduction, a Section with my Matlab code, a Section with outputs from my code. In addiiton, I would like to represent my diary about this project.

2 Pivoting to Optimality

1. My initial tableau is canonical form, all values of the col. 1 are positive. DSM.m has been presented in my code.

2. I finally used my function m-file SM.m to pivot T_0 to OF — T_9.

3 Matlab code

3.1 DSM

```
function T = DSM(T0)
[~,pos]=min(T0(2:end,1));
pos=pos+1;
r=pos;
negcols = find(T0(r,2:end)<0);
negcols = negcols+1;
colrat=T0(1,negcols)./T0(r,negcols);
[~,pos]=max(colrat);
c=negcols(pos);
T =Pivot(T0,r,c);
end
```

3.2 SM

```
function T = SM(T0)
[~,pos]=min(T0(1,2:end));pos=pos+1;
c=pos;
```

```
posrows = find(T0(2:end,c)>0);
posrows = posrows+1;
rowrat=T0(posrows,1)./T0(posrows,c);
[~,pos]=min(rowrat);
r=posrows(pos);
T =Pivot(T0,r,c);
end
```

3.3 Pivot

```
function Tout=Pivot(T,row,col)


% PIVOT
% Input: T is a Simplex Tableau in Standard Form
%        pivot row & column indices.
%        Number the rows & columns from 1 (incl top row & LH column).
% Output: Tout is result of pivoting on T using specified pivot.
%
% Example: T1=Pivot(T0,row_num,col_num);


[m,n]=size(T);
p=T(row,col);
fprintf('Row %i and Col %i selected.\n',row,col)
T(row,:)=T(row,:)/p;
for i=1:row-1
    p=T(i,col);
    T(i,:)=T(i,:)-p*T(row,:);
end;
for i=row+1:m
    p=T(i,col);
    T(i,:)=T(i,:)-p*T(row,:);
end;
Tout=T;
```

3.4 The Optimal Tableau(T9)

	1	2	3	4	5	6	7	8	9	10	11
1	552.7928	9.5443	0	3.6190	0	0	0	8.7689	0	1.2494	0.8495
2	127.9248	0.1067	0	4.4729	0	0	0	0.4777	0	-0.9083	4.5869
3	81.4692	-4.4415	0	-0.5536	0	0	0	-0.2783	0	2.5010	7.9757
4	22.8253	0.3933	0	0.0271	0	0	1	0.0223	0	0.4083	0.4131
5	9.2813	-0.6897	0	0.8333	0	1	0	-0.1178	0	0.2455	-0.0535
6	14.7791	0.5904	0	-0.1919	1	0	0	0.3654	0	-0.1829	-0.7402
7	31.3322	0.4573	1	-0.1159	0	0	0	0.4757	0	0.3929	0.8012
8	83.5933	3.6723	0	-8.6669	0	0	0	0.6757	0	5.2184	4.6258
9	225.5683	1.1636	0	-1.0837	0	0	0	2.4547	0	-1.5496	10.9120
10	26.0393	0.0232	0	0.4448	0	0	0	-0.0773	1	0.0481	0.5702
11	83.5663	4.6777	0	-4.3232	0	0	0	-2.1755	0	5.0259	3.1282

Figure 1: The caption of this figure.

12	13	14	15	16	17	18	19	20	21
0	1.0843	0	0.0877	0	0.3698	1.4195	0	1.2041	0
1	0.4231	0	0.6009	0	-0.5507	-0.0412	0	-0.6275	0
0	0.4986	0	0.4935	1	-0.4297	-0.1292	0	-0.1811	0
0	0.0769	0	-0.1009	0	0.0507	0.0412	0	0.1275	0
0	0.0898	0	0.1139	0	0.0886	-0.0635	0	-0.0716	0
0	-0.0691	0	-0.0936	0	0.0215	0.1361	0	-0.0477	0
0	0.0992	0	0.0039	0	-0.0743	0.1091	0	0.0249	0
0	0.1289	1	-0.7028	0	-0.8801	0.5552	0	-0.0012	0
0	0.2383	0	0.5028	0	-0.7759	0.3010	1	0.4624	0
0	0.0416	0	0.1185	0	0.0554	0.0112	0	0.0970	0
0	0.0737	0	0.2691	0	-0.5617	-0.0163	0	0.7620	1

Figure 2: The caption of this figure.

3.5 Project$_A(a)$

```
function T = askAa(Ta)
Ta = T9;
nonbasic = find(Ta(1, :)>0);
fprintf("the last nonbasic column")
%the last nonbasic column
lnbcol = max(nonbasic);
lnbcol
lastnonbasic = Ta(: , lnbcol);
fprintf("the raws of positive values")
%the raws of positive values
posrow = find(Ta (2:end, lnbcol) >0) +1;
posrow
%values of row ratio
posrats = Ta(posrow, 1)./Ta(posrow, lnbcol);

fprintf("the minimum row ratio")
%the minimum row ratio value
```

```
minrat = min(posrats);
minrat
fprintf("X is half of minimum row ratio")
X = minrat/2;
X
Ta(:,1) = Ta(:,1)-Ta(:, lnbcol)*X;
%Checker
AaT0 = T9;
newrowa = zeros(1,21);
newrowa(1) = X;
newrowa(lnbcol) = 1;
newrowa

AaT0 = [AaT0; newrowa];
[m,n] = size(AaT0);
AaT0 = Pivot(AaT0, m, lnbcol);
AaT0
Ta
AaT0(:, 1)
Ta(:, 1)


end
```

3.6 Project$_A(b)$

```
function T1 = askAb(Tb)
Tb = T9;
basicAb = find(Tb(1, :)==0);
%The last basic variables column
mbcol = max(basicAb);
fprintf("The last basic variables column")
mbcol

%Find the row of "1" in the col.mbcol
brow1 = find(Tb(:,mbcol)==1);
fprintf("The columns of negative in %d rows\n",brow1)
%The columns of negative in %d rows
bcolneg = find(Tb(brow1,:)<0);
fprintf("%d        ",bcolneg)
fprintf("\n")
fprintf("Calculate the ratios of the cost(Row 1) in each of these columns with n
%The row 1./ row brow1 with negative
bcolratio = Tb(1,bcolneg)./Tb(brow1,bcolneg);
bcolratio
%Find the max value of ratio
```

```
bcolratiomax = max(bcolratio(1,:));

fprintf("The best col position")
%best col position
posicolmax0 = find(bcolratio(1,:)==bcolratiomax);
posicolmax = bcolneg(1,posicolmax0);
posicolmax

%Find the rows of positive
posrowb = find(Tb(2:end,posicolmax)>0)+1;
%Values of row ratio
posratesb = Tb(posrowb,1)./Tb(posrowb,posicolmax);
fprintf("The mmr for %d \n",mbcol)
%The mmr for
minratb = min(posratesb);
Xb = minratb/2;
Xb
Tb(:,1)=Tb(:,1)-Tb(:, posicolmax)*Xb;
%Checker
AbT = T9;
b11 = Tb(brow1,1);
newrowab = zeros(1,21);
newrowab(1) = b11;
newrowab(mbcol) = 1;
AbT = [AbT; newrowab];
[mb,nb] = size(AbT);
AbT = Pivot(AbT,mb,mbcol);
AbT = DSM(AbT);
AbT(:,1)
Tb(:,1)

end
```

3.7 Project$_A(c)$

```
function T2 = askAc(Tc)
Tc = T9;
Tc0 = Tc;
Tc0(:,1) = [];
nonbasicAc = find(Tc0(1,2:end)>0);
fprintf("The first nonbasic variables col.")
%The first nonbasic variables col.
minnonbasicAc = min(nonbasicAc);
minnonbasicAc
fprintf("The positive rows")
%The positive rows
```

```
posrow0 = find(Tc(2:end,minnonbasicAc)>0)+1;
posrow0
%row ratio
posroratesw0 = Tc(posrow0,1)./Tc(posrow0,minnonbasicAc);
%the minimum raw ratio
minposroratesw0 = min(posroratesw0);
fprintf("The raw the min raw ratio\n")
minposroratesw0
posirowmin0 = find(posroratesw0(:,1)==minposroratesw0);
posirowmin = posrow0(posirowmin0,1);
fprintf("%d\n",posirowmin)
Tc = Pivot(Tc,posirowmin,minnonbasicAc);

fprintf("The columns of negative in %d rows\n",posirowmin)
%The columns of negative in %d rows
ccolneg = find(Tc(posirowmin,2:end)<0)+1;
ccolneg
fprintf("Calculate the ratios of the cost(Row 1) in each of these columns with n
ccolratio = Tc(1,ccolneg)./Tc(posirowmin,ccolneg);
ccolratio
maxccolratio = max(ccolratio);
fprintf("The best col")
%The best col
positioncolmax0 = find(ccolratio(1,:)==maxccolratio);
positioncolmax = ccolneg(1,positioncolmax0);
positioncolmax

%row ratio
newposrowc0 = find(Tc(2:end,positioncolmax)>0)+1;
newposrowc = Tc(newposrowc0,1)./Tc(newposrowc0,positioncolmax);
minnewposrowc = min(newposrowc);
Xc = minnewposrowc/2;
Xc

%Checker
Tc(:,1) =Tc(:,1)- Tc(:,positioncolmax)*Xc;

AcT = T9;
c11 = Tc(posirowmin,1);
newrowac = zeros(1,21);
newrowac(1) = c11;
newrowac(minnonbasicAc) = 1;
AcT = [AcT;newrowac];

[mc,nc] = size(AcT);
AcT = Pivot(AcT,mc,minnonbasicAc);
```

```
AcT = DSM(AcT);
AcT = Pivot(AcT, posirowmin, positioncolmax);
AcT(:,1)
Tc(:,1)

end
```

3.8 Project$_B$

```
function T = askB(TB)
TB = T9;
nonbasicB0 = find(TB(1,2:end)>0)+1;
%Last non-basic slack col is  %d\n
nonbasicB = max(nonbasicB0);
fprintf("Last non-basic slack col is  %d\n",nonbasicB)
%Find the rows of positive in col.onbasicB
posnbrowB =find(TB(2:end,nonbasicB)>0)+1
%Find the rows of negetive in col.onbasicB
negnbrowB =find(TB(2:end,nonbasicB)<0)+1
 %range
minnbrowB0 = -TB(posnbrowB,1)./TB(posnbrowB,nonbasicB)
maxnbrowB0 = -TB(negnbrowB,1)./TB(negnbrowB,nonbasicB)
minnbrowB = max(minnbrowB0)
maxnbrowB = min(maxnbrowB0)
fprintf("The range of a:  %f <=  a  <= %f\n",minnbrowB,maxnbrowB)
aB = maxnbrowB/2
TB(:,1) = TB(:,1) + TB(:,nonbasicB)*aB;
%Checker
TB1 = T0;
TB1(10, 1) = TB1(10, 1) + aB;
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1 = SM(TB1);
TB1(:,1)
TB(:,1)
end
```

3.9 Project$_C$

```
function T = askC(TC)
```

```
TC = T9;
TC0 = T9;
basicC = find(TC(1, :)==0);
nonbasicC = find(TC(1,2:end)>0)+1;
fprintf("The first basic variables col.")
%The first basic variables col.
minbasicC = min(basicC);
minbasicC

%defined in row %d\n
basicfirstC = find(TC(:,minbasicC)==1);
fprintf("defined in row %d\n",basicfirstC)
fprintf("The positive position",basicfirstC)
%The positive position
posnbcolC = find(TC(basicfirstC,2:end)>0)+1;
posnbcolC
fprintf("I will remove 3 from posnbcolC\n")
%I will remove 3 from posnbcolC
posnbcolC(:,2) = []
fprintf("The negative")
%The negative
negnbcolC = find(TC(basicfirstC,:)<0)
minnbcolC0 = -TC(1,posnbcolC)./TC(basicfirstC,posnbcolC);
maxnbcolC0 = -TC(1,negnbcolC)./TC(basicfirstC,negnbcolC);
minnbcolC = max(minnbcolC0)
maxnbcolC = min(maxnbcolC0)
%The range
fprintf("The range of a: %f <= qc <= %f\n",minnbcolC,maxnbcolC)
qc = max(-TC(1,posnbcolC)./TC(basicfirstC,posnbcolC))/2
%Add the 7 row to 1 row
TC0(1,:) = TC0(1,:) + TC0(basicfirstC,:) * qc;
TC0(1,minbasicC)=0;
TC2 = T0;
TC2(1, minbasicC) = TC2(1, minbasicC) - qc;
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2 = SM(TC2);
TC2(1, :)
TC0(1, :)
end
```

4 Outputs

4.1 A(a)

```
the last nonbasic column
lnbcol =

         20.00

the raws of positive values
posrow =

          4.00
          7.00
          9.00
         10.00
         11.00

the minimum row ratio
minrat =

        109.66

X is half of minimum row ratio
X =

         54.83


newrowa =

  col. 1 to 8

54.83    0       0       0       0       0       0       0

  col. 9 to 16
0        0       0       0       0       0       0       0

 col. 17 to 21

0        0       0      1.00     0

Row 12 and Col 20 selected.

AaT0 =
```

col. 1 to 8

486.77	9.54	0	3.62	0	0	0	8.77
162.33	0.11	0	4.47	0	0	0	0.48
91.40	−4.44	0	−0.55	0	0	0	−0.28
15.83	0.39	0	0.03	0	0	1.00	0.02
13.21	−0.69	0	0.83	0	1.00	0	−0.12
17.39	0.59	0	−0.19	1.00	0	0	0.37
29.97	0.46	1.00	−0.12	0	0	0	0.48
83.66	3.67	0	−8.67	0	0	0	0.68
200.21	1.16	0	−1.08	0	0	0	2.45
20.72	0.02	0	0.44	0	0	0	−0.08
41.78	4.68	0	−4.32	0	0	0	−2.18
54.83	0	0	0	0	0	0	0

col. 9 to 16

0	1.25	0.85	0	1.08	0	0.09	0
0	−0.91	4.59	1.00	0.42	0	0.60	0
0	2.50	7.98	0	0.50	0	0.49	1.00
0	0.41	0.41	0	0.08	0	−0.10	0
0	0.25	−0.05	0	0.09	0	0.11	0
0	−0.18	−0.74	0	−0.07	0	−0.09	0
0	0.39	0.80	0	0.10	0	0.00	0
0	5.22	4.63	0	0.13	1.00	−0.70	0
0	−1.55	10.91	0	0.24	0	0.50	0
1.00	0.05	0.57	0	0.04	0	0.12	0
0	5.03	3.13	0	0.07	0	0.27	0
0	0	0	0	0	0	0	0

col. 17 to 21

0.37	1.42	0	0	0
−0.55	−0.04	0	0	0
−0.43	−0.13	0	0	0
0.05	0.04	0	0	0
0.09	−0.06	0	0	0
0.02	0.14	0	0	0
−0.07	0.11	0	0	0
−0.88	0.56	0	0	0
−0.78	0.30	1.00	0	0
0.06	0.01	0	0	0
−0.56	−0.02	0	0	1.00
0	0	0	1.00	0

```
Ta =

  col. 1 to 8

486.77    9.54    0    3.62    0    0    0    8.77
162.33    0.11    0    4.47    0    0    0    0.48
91.40    −4.44    0   −0.55    0    0    0   −0.28
15.83    0.39    0    0.03    0    0    1.00    0.02
13.21   −0.69    0    0.83    0    1.00    0   −0.12
17.39    0.59    0   −0.19    1.00    0    0    0.37
29.97    0.46    1.00   −0.12    0    0    0    0.48
83.66    3.67    0   −8.67    0    0    0    0.68
200.21    1.16    0   −1.08    0    0    0    2.45
20.72    0.02    0    0.44    0    0    0   −0.08
41.78    4.68    0   −4.32    0    0    0   −2.18

  col. 9 to. 16

 0    1.25    0.85    0    1.08    0    0.09    0
 0   −0.91    4.59    1.00    0.42    0    0.60    0
 0    2.50    7.98    0    0.50    0    0.49    1.00
 0    0.41    0.41    0    0.08    0   −0.10    0
 0    0.25   −0.05    0    0.09    0    0.11    0
 0   −0.18   −0.74    0   −0.07    0   −0.09    0
 0    0.39    0.80    0    0.10    0    0.00    0
 0    5.22    4.63    0    0.13    1.00   −0.70    0
 0   −1.55   10.91    0    0.24    0    0.50    0
1.00    0.05    0.57    0    0.04    0    0.12    0
 0    5.03    3.13    0    0.07    0    0.27    0

  col. 17 to. 21

 0.37    1.42    0    1.20    0
−0.55   −0.04    0   −0.63    0
−0.43   −0.13    0   −0.18    0
 0.05    0.04    0    0.13    0
 0.09   −0.06    0   −0.07    0
 0.02    0.14    0   −0.05    0
−0.07    0.11    0    0.02    0
−0.88    0.56    0   −0.00    0
−0.78    0.30    1.00    0.46    0
 0.06    0.01    0    0.10    0
−0.56   −0.02    0    0.76    1.00


ans =
```

```
        486.77
        162.33
         91.40
         15.83
         13.21
         17.39
         29.97
         83.66
        200.21
         20.72
         41.78
         54.83


ans =

        486.77
        162.33
         91.40
         15.83
         13.21
         17.39
         29.97
         83.66
        200.21
         20.72
         41.78
```

4.2 A(b)

```
The last basic variables column
mbcol =

         21.00

The columns of negative in 11 rows
4       8       17       18
Calculate the ratios of the cost(Row 1) in each of these columns with negative n
bcolratio =

         -0.84          -4.03          -0.66         -87.00

The best col position
posicolmax =
```

```
          17.00

The mmr for 21

Xb =

          52.40

Row 12 and Col 21 selected.
Row 11 and Col 17 selected.

ans =

         533.41
         156.78
         103.99
          20.17
           4.64
          13.65
          35.22
         129.71
         266.23
          23.14
         113.00
          52.40


ans =

         533.41
         156.78
         103.99
          20.17
           4.64
          13.65
          35.22
         129.71
         266.23
          23.14
         113.00
```

4.3 A(c)

```
The first nonbasic variables col.
minnonbasicAc =
```

```
           2.00

The positive rows
posrow0 =

           2.00
           4.00
           6.00
           7.00
           8.00
           9.00
          10.00
          11.00

The raw the min raw ratio
11
Row 11 and Col 2 selected.
The columns of negative in 11 rows

ccolneg =

           4.00           8.00          17.00          18.00

Calculate the ratios of the cost(Row 1) in each of these columns with negative n

ccolratio =

         -13.46         -28.40         -12.62        -416.50

The best col
positioncolmax =

          17.00


Xc =

          22.91

Row 12 and Col 2 selected.
Row 11 and Col 17 selected.
Row 11 and Col 17 selected.

ans =

         347.55
```

```
        138.34
        182.88
         13.56
         21.47
          2.12
         23.61
         28.05
        219.35
         24.29
         22.91
         20.62


ans =

        347.55
        138.34
        182.88
         13.56
         21.47
          2.12
         23.61
         28.05
        219.35
         24.29
         20.62
```

4.4 B

```
Last non-basic slack col is  20

posnbrowB =

     4
     7
     9
    10
    11


negnbrowB =

     2
     3
     5
     6
```

```
      8


minnbrowB0 =

    1.0e+03 *

   -0.1790
   -1.2582
   -0.4878
   -0.2683
   -0.1097


maxnbrowB0 =

    1.0e+04 *

    0.0204
    0.0450
    0.0130
    0.0310
    7.0796


minnbrowB =

  -109.6639


maxnbrowB =

   129.6318

The range of a:  -109.663862 <=  a  <= 129.631762

aB =

    64.8159

Row 5 and Col 9 selected.
Row 4 and Col 7 selected.
Row 10 and Col 3 selected.
Row 7 and Col 6 selected.
Row 3 and Col 11 selected.
Row 6 and Col 5 selected.
```

```
Row 8 and Col 10 selected.
Row 8 and Col 14 selected.
Row 3 and Col 16 selected.

ans =

  630.8349
   87.2514
   69.7319
   31.0908
   32.3289
   11.6900
    4.6406
   83.5168
  255.5411
   32.9463
  132.9575


ans =

  630.8349
   87.2514
   69.7319
   31.0908
    4.6406
   11.6900
   32.9463
   83.5168
  255.5411
   32.3289
  132.9575
```

4.5 C

```
The first basic variables col.
minbasicC =

          3.00

defined in row  7
The positive position
posnbcolC =

  col. 1 to 8
```

```
2.00    3.00    8.00    10.00    11.00    13.00    15.00    18.00

  col. 9

20.00

I will remove 3 from posnbcolC

posnbcolC =

2.00    8.00    10.00    11.00    13.00    15.00    18.00    20.00

The negative
negnbcolC =

           4.00           17.00


minnbcolC =

          -1.06


maxnbcolC =

           4.98

The range of a:  -1.060289 <=  qc  <= 4.978324

qc =

          -0.53

Row 10 and Col 9 selected.
Row 5  and Col 6 selected.
Row 4  and Col 7 selected.
Row 7  and Col 3 selected.
Row 3  and Col 11 selected.
Row 6  and Col 5 selected.
Row 8  and Col 10 selected.
Row 8  and Col 14 selected.
Row 3  and Col 16 selected.

ans =

  col. 1 to 8
```

```
536.18    9.30    0    3.68    0    0    0    8.52

  col. 9 to 16

0         1.04   0.42   0      1.03  0   0.09    0

  col. 17 to 21

0.41      1.36    0    1.19    0


ans =

  col. 1 to 8

536.18    9.30    0    3.68    0    0    0    8.52

  col. 9 to 16

0         1.04   0.42   0      1.03  0   0.09    0

  col. 17 to 21

0.41      1.36    0    1.19    0
```

5 Explanations and Flow Path

5.1 Changes in nonbasic variables

1. If the required increase in a nonbasic variables, Xk is less than the minimum row ratio for the Xk col.
2. Then to get a new optimal vector, set Xk to the required new value and keep all other nonbasic variables 0.
3. Next the new value of Xk into the basic variables to update them.

5.2 Increasing basic variables

1. An increase in a basic variable in our row r of P* is possible, only if some element of row r is negative (ark ¡0)
2. The new Optimal Vector is founded by increasing the nonbasic variable Xk, Where k is chosen to be the columns with ark¡0 that maximum ck./ark
3. Provided that the increase in Xk necessary to achieve the increase in the basic variable does NOT exceed the minimum row ratio for the Xk column.

5.3 When a Nonbasic Variable becomes Basic and Exceeds its Minimum Row Ratio

An increase in a nonbasic variable Xk, whose MRR is in row r of P* above that MRR. Then 2 STEPS
1) First pivoting on (r,k) element of the tableau to make Xk basic.
2) Using the technique above for increasing basic variables.

5.4 Changes in a single resource

1. Range.
2. Increase the value of the slack variables for a resource is equivalent to decreasing the availability of that resources. Similarly, increase the availability of resources is equivalent to decrease the slack variables for the resource.

5.5 Changes in objective coefficients

1. Range.
2. The Optimal Vector does not change.
3. The Optimal value Changes by q*X where Xk* is the value in the optimal tableau of the variable whose selling price is chaged.

6 End of Project

References

John K. (2019) MS4303: Operation Research 1, University of Limerick, availablehttp://jkcray.maths.ul.ie/ms4303/Slides.pdf