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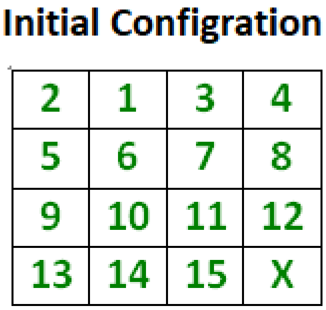
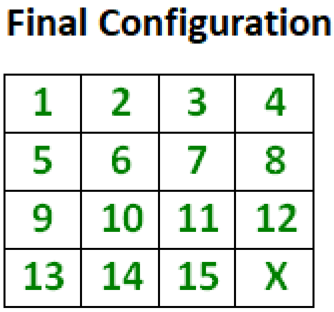
SUBJECT	Design and Analysis of Algorithm
EXPERIMENT NO :	08
DATE OF PERFORMANCE	10/04/2023
DATE OF SUBMISSION	17/04/2023
AIM:	To use Branch and bound to solve 15 puzzle problem
PROBLEM STATEMENT 1:	15 Puzzle Problem
ALGORITHM and THEORY:	Given a 4×4 board with 15 tiles (every tile has one number from 1 to 15) and one empty space. The objective is to place the numbers on tiles in order using the empty space. We can slide four adjacent (left, right, above and below) tiles into the empty space. For example,



Initial Configration

2	1	3	4
5	6	7	8
9	10	11	12
13	14	15	X



Final Configuration

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	X

Here X marks the spot to where the elements can be shifted and the final configuration always remains the same the puzzle is solvable. In general, for a given grid of width N, we can find out check if a N*N – 1 puzzle is solvable or not by following below simple rules :

1. If N is odd, then puzzle instance is solvable if number of inversions is even in the input state.
2. If N is even, puzzle instance is solvable if
    - the blank is on an even row counting from the bottom (second-last, fourth-last, etc.) and number of inversions is odd.
    - the blank is on an odd row counting from the bottom (last, third-last, fifth-last, etc.) and number of inversions is even.
3. For all other cases, the puzzle instance is not solvable.

What is an inversion here?

PROGRAM:

```
#include<stdio.h>
#include<conio.h>

int m=0,n=4;

int cal(int temp[10][10],int t[10][10])
{
        int i,j,m=0;
        for(i=0;i < n;i++)
                for(j=0;j < n;j++)
                {
                        if(temp[i][j]!=t[i][j])
                        m++;
                }
        return m;
}

int check(int a[10][10],int t[10][10])
{
        int i,j,f=1;
        for(i=0;i < n;i++)
                for(j=0;j < n;j++)
                        if(a[i][j]!=t[i][j])
                                f=0;
        return f;
}



void main()
{
        int p,i,j,n=4,a[10][10],t[10][10],temp[10][10],r[10][10];
        int m=0,x=0,y=0,d=1000,dmin=0,l=0;
        clrscr();
        printf("\nEnter the matrix to be solved,space with zero :\n");
        for(i=0;i < n;i++)
                for(j=0;j < n;j++)
                        scanf("%d",&a[i][j]);

        printf("\nEnter the target matrix,space with zero :\n");
        for(i=0;i < n;i++)
                for(j=0;j < n;j++)
                        scanf("%d",&t[i][j]);

        printf("\nEntered Matrix is :\n");
        for(i=0;i < n;i++)
        {
                for(j=0;j < n;j++)
                        printf("%d\t",a[i][j]);
                printf("\n");
        }

        printf("\nTarget Matrix is :\n");
        for(i=0;i < n;i++)
        {
                for(j=0;j < n;j++)
                        printf("%d\t",t[i][j]);
                printf("\n");
        }

        while(!(check(a,t)))
        {
                l++;
                d=1000;
```

```
for(i=0;i < n;i++)
        for(j=0;j < n;j++)
        {
                if(a[i][j]==0)
                {
                        x=i;
                        y=j;
                }
        }

//To move upwards
for(i=0;i < n;i++)
        for(j=0;j < n;j++)
                temp[i][j]=a[i][j];

if(x!=0)
{
        p=temp[x][y];
        temp[x][y]=temp[x-1][y];
        temp[x-1][y]=p;
}
m=cal(temp,t);
dmin=l+m;
if(dmin < d)
{
        d=dmin;
        for(i=0;i < n;i++)
                for(j=0;j < n;j++)
                        r[i][j]=temp[i][j];
}

//To move downwards
for(i=0;i < n;i++)
```

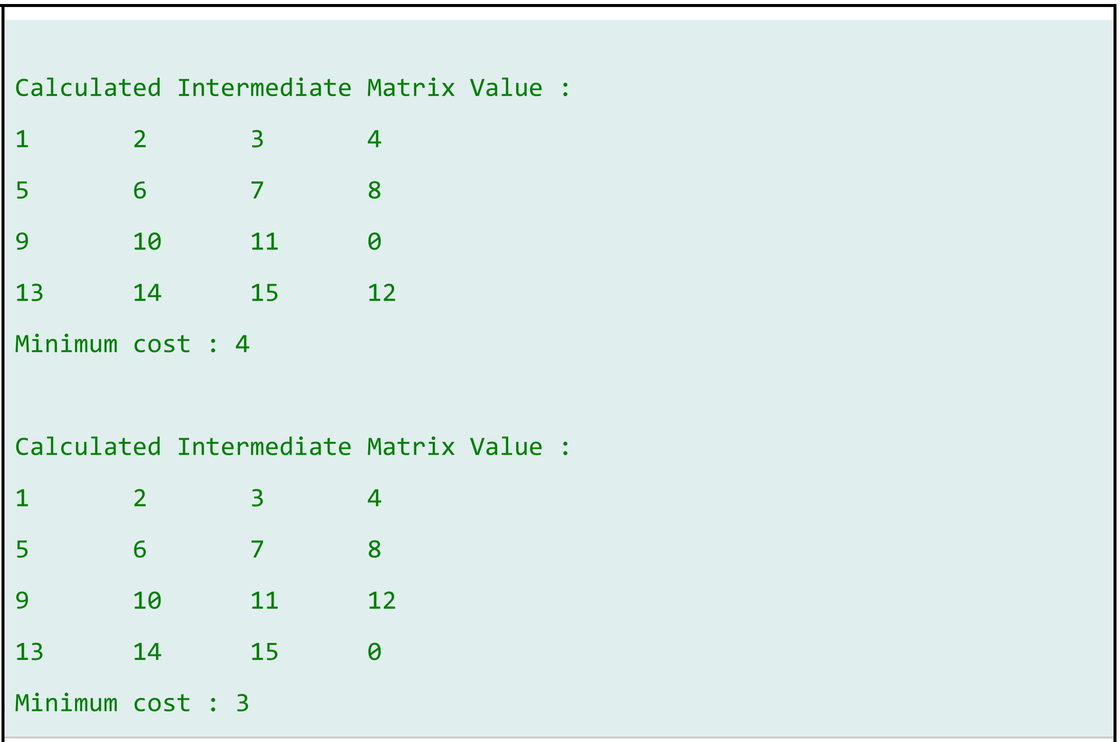
```
                        for(j=0;j < n;j++)
                                temp[i][j]=a[i][j];
                if(x!=n-1)
                {
                        p=temp[x][y];
                        temp[x][y]=temp[x+1][y];
                        temp[x+1][y]=p;
                }
                m=cal(temp,t);
                dmin=l+m;
                if(dmin < d)
                {
                        d=dmin;
                        for(i=0;i < n;i++)
                                for(j=0;j < n;j++)
                                        r[i][j]=temp[i][j];
                }

                //To move right side
                for(i=0;i < n;i++)
                        for(j=0;j < n;j++)
                                temp[i][j]=a[i][j];
                if(y!=n-1)
                {
                        p=temp[x][y];
                        temp[x][y]=temp[x][y+1];
                        temp[x][y+1]=p;
                }
                m=cal(temp,t);
                dmin=l+m;
                if(dmin < d)
                {
                        d=dmin;
                for(i=0;i < n;i++)
                        for(j=0;j < n;j++)
                                r[i][j]=temp[i][j];
        }

        //To move left
        for(i=0;i < n;i++)
                for(j=0;j < n;j++)
                        temp[i][j]=a[i][j];
        if(y!=0)
        {
                p=temp[x][y];
                temp[x][y]=temp[x][y-1];
                temp[x][y-1]=p;
        }
        m=cal(temp,t);
        dmin=l+m;
        if(dmin < d)
        {
                d=dmin;
                for(i=0;i < n;i++)
                        for(j=0;j < n;j++)
                                r[i][j]=temp[i][j];
        }

        printf("\nCalculated Intermediate Matrix Value :\n");
        for(i=0;i < n;i++)
        {
                for(j=0;j < n;j++)
                  printf("%d\t",r[i][j]);
                printf("\n");
        }
        for(i=0;i < n;i++)
```

```
                         for(j=0;j < n;j++)
                         {
                           a[i][j]=r[i][j];
                           temp[i][j]=0;
                         }
                 printf("Minimum cost : %d\n",d);
        }
        getch();
}
```

OUTPUT:

```
Enter the matrix to be solved,space with zero:
1
2
3
4
5
6
0
8
9
10
7
11
13
14
15
12

Enter the target matrix,space with zero :
1
2
```

```
3
4
5
6
7
8
9
10
11
12
13
14
15
0

Entered Matrix is :
1       2       3       4
5       6       0       8
9       10      7       11
13      14      15      12

Target Matrix is :
1       2       3       4
5       6       7       8
9       10      11      12
13      14      15      0

Calculated Intermediate Matrix Value :
1       2       3       4
5       6       7       8
9       10      0       11
13      14      15      12
Minimum cost : 4
```



```
Calculated Intermediate Matrix Value :
1       2       3       4
5       6       7       8
9       10      11      0
13      14      15      12
Minimum cost : 4

Calculated Intermediate Matrix Value :
1       2       3       4
5       6       7       8
9       10      11      12
13      14      15      0
Minimum cost : 3
```

CONCLUSION:

By performing the above experiment I was able to implement the 15 Puzzle problem to print the solution matrix every time And also the minimum cost