Natural Language Processing (NLP)

Lab - 2.

1) 2.4). Compute the edit distance (using insertion cost 1, deletion cost 1, substitution cost 1) of "leda" to "deal". Prepare an edit distance grid to complete your work.

Solution:- To calculate edit distance, we take dynamic approach. This dynamic approach to calculate edit distance is Levenshtein formula :-

$$D(i,j) = \min \begin{cases} D(i-1,j) + 1 & \text{Deletion} \\ D(i,j-1) + 1 & \text{Insertion} \\ D(i-1,j-1) + \text{cost} & \text{Substitution.} \end{cases}$$

The cost operations included here are — deletion, insertion and substitution.

$$\text{cost} = \begin{cases} 0, & \text{if } A[i-1] = B[j-1] \\ 1, & \text{if } A[i-1] \neq B[j-1], \end{cases}$$

where, let A be the source string, i.e, A = "leda" and B be the target string, i.e, B = "deal".

Here, i is the number of characters of A ("leda") and j is the number of characters of B ("deal"), i.e, i rows and j columns.

The edit distance grid will be $(i+1) \times (j+1)$, i.e, 5×5.

		0	1	2	3	4
		–	d	e	a	l
0	–	0	1	2	3	4
1	l	1				
2	e	2				
3	d	3				
4	a	4				

Calculating row by row :-

Row-1 (i=1) :- [Comparing "l" with each character in "deal"].

1) l ≠ d.

∴ cost = 1.

$$D(1,1) = \min \begin{cases} D(0,1)+1 \\ D(1,0)+1 \\ D(0,0)+cost \end{cases}$$

$$= \min \begin{cases} 2 \\ 2 \\ 1 \end{cases}$$

$$= 1.$$

2) l ≠ e.

∴ cost = 1.

$$D(1,2) = \min \begin{cases} D(0,2)+1 \\ D(1,1)+1 \\ D(0,1)+cost \end{cases}$$

$$= \min \begin{cases} 3 \\ 2 \\ 2 \end{cases}$$

$$= 2.$$

3) l ≠ a

∴ cost = 1

$$D(1,3) = \min \begin{cases} D(0,3)+1 \\ D(1,2)+1 \\ D(0,2)+cost \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 3 \end{cases} = 3.$$

4) $l = l$.

$\therefore$ Cost = 0.

$$D(1,4) = \min \begin{cases} D(0,4)+1 \\ D(1,3)+1 \\ D(0,3)+\text{Cost} \end{cases}$$

$$= \min \begin{cases} 5 \\ 4 \\ 3 \end{cases}$$

$$= 3.$$

$\therefore$ Distance guid —

		0	1	2	3	4
		–	d	e	a	l
0	–	0	1	2	3	4
1	l	1	1	2	3	3
2	e	2				
3	d	3				
4	a	4				

Row-2 (i=2): [Comparing "e" with each character of "deal"].

1) $e \neq d$.

$\therefore$ Cost = 1.

$$D(2,1) = \min \begin{cases} D(1,1)+1 \\ D(2,0)+1 \\ D(1,0)+\text{Cost} \end{cases}$$

$$= \min \begin{cases} 2 \\ 3 \\ 2 \end{cases}$$

$$= 2.$$

2) $e = e$.

$\therefore$ Cost = 0.

$$D(2,2) = \min \begin{cases} D(1,2) + 1 \\ D(2,1) + 1 \\ D(1,1) + \text{Cost} \end{cases}$$

$$= \min \begin{cases} 3 \\ 3 \\ 1 \end{cases}$$

$$= 1.$$

3) $e \neq a$.

$\therefore$ Cost = 1.

$$D(2,3) = \min \begin{cases} D(1,3) + 1 \\ D(2,2) + 1 \\ D(1,2) + \text{Cost} \end{cases}$$

$$= \min \begin{cases} 4 \\ 2 \\ 3 \end{cases}$$

$$= 2.$$

4) $e \neq l$.

$\therefore$ Cost = 1.

$$D(2,4) = \min \begin{cases} D(1,4) + 1 \\ D(2,3) + 1 \\ D(1,3) + \text{Cost} \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 4 \end{cases}$$

$$= 3.$$

∴ Distance guild —

		0	1	2	3	4
		-	d	e	a	l
0	-	0	1	2	3	4
1	l	1	1	2	3	3
2	e	2	2	1	2	3
3	d	3				
4	a	4				

Row-3 (i=3):- [Comparing "d" with each character in "deal"].

1) d = d.

∴ Cost = 0.

$$D(3,1) = \min \begin{cases} D(2,1) + 1 \\ D(3,0) + 1 \\ D(2,0) + \text{cost} \end{cases}$$

$$= \min \begin{cases} 3 \\ 4 \\ 2 \end{cases}$$

$$= 2.$$

2) d ≠ e.

∴ Cost = 1.

$$D(3,2) = \min \begin{cases} D(2,2) + 1 \\ D(3,1) + 1 \\ D(2,1) + 1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 3 \\ 3 \end{cases} = 2.$$

3) $d \neq a$.

$\therefore$ Cost = 1.

$$D(3,3) = \min \begin{cases} D(2,3)+1 \\ D(3,2)+1 \\ D(2,2)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 3 \\ 2 \end{cases}$$

$= 2$.

4) $d \neq l$.

$\therefore$ Cost = 1.

$$D(3,4) = \min \begin{cases} D(2,4)+1 \\ D(3,3)+1 \\ D(2,3)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 3 \end{cases}$$

$= 3$.

$\therefore$ Distance guid —

		0	1	2	3	4
		-	d	e	a	l
0	-	0	1	2	3	4
1	l	1	1	2	3	3
2	e	2	2	1	2	3
3	d	3	2	2	2	3
4	a	4				

Row-4 (i=4):- [Comparing "a" with each character in "deal"]

1) $a \neq d$.

$\therefore$ Cost = 1.

$$D(4,1) = \min \begin{cases} D(3,1)+1 \\ D(4,0)+1 \\ D(3,0)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 5 \\ 4 \end{cases}$$

$$= 3.$$

2) $a \neq e$.

$\therefore$ Cost = 1.

$$D(4,2) = \min \begin{cases} D(3,2)+1 \\ D(4,1)+1 \\ D(3,1)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 4 \\ 3 \end{cases}$$

$$= 3.$$

3) $a = a$.

$\therefore$ Cost = 0.

$$D(4,3) = \min \begin{cases} D(3,3)+1 \\ D(4,2)+1 \\ D(3,2)+0 \end{cases}$$

$$= \min \begin{cases} 3 \\ 4 \\ 2 \end{cases} = 2.$$

4) $a \neq l$.

$\therefore$ Cost = 1.

$$D(4,4) = \min \begin{cases} D(3,4)+1 \\ D(4,3)+1 \\ D(3,3)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 3 \end{cases}$$

$$= 3.$$

$\therefore$ Distance guid —

	-	d	e	a	l
-	0	1	2	3	4
l	1	1	2	3	3
e	2	2	1	2	3
d	3	2	2	2	3
a	4	3	3	2	3

$\therefore$ The edit distance (using insertion cost 1, deletion cost 1, substitution cost 1) of "leda" to "deal" is 3 units.

i) 2.5). Find out whether the "drive" is closer to "brief" or to "divers" and what edit distance is to each. You may use any version of distance that you like.

Solution: To calculate the edit distance of "drive" to "brief" and "divers", we use Levenshtein distance method, which is an example of dynamic programming.

$$D(i,j) = \min \begin{cases} D(i-1,j)+1 & \text{Deletion} \\ D(i,j-1)+1 & \text{Insertion} \\ D(i-1,j-1)+\text{cost} & \text{Substitution.} \end{cases}$$

$$\text{cost} = \begin{cases} 0, & A[i-1] = B[j-1] \\ 1, & A[i-1] \neq B[j-1]. \end{cases}$$

Let us start with an empty distance grid of order $(i+1 \times j+1)$ i.e, of order 6×6.

Here, A = drive, source

and B = brief, target.

		0	1	2	3	4	5
		–	b	u	i	e	f
0	–	0	1	2	3	4	5
1	d	1					
2	u	2					
3	i	3					
4	v	4					
5	e	5					

Row-1 (i=1) :-

1) d ≠ b.

∴ Cost = 1.

$$D(1,1) = \min \begin{cases} D(0,1)+1 \\ D(1,0)+1 \\ D(0,0)+1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 2 \\ 1 \end{cases}$$

$$= 1.$$

2) d ≠ u.

∴ Cost = 1.

$$D(1,2) = \min \begin{cases} D(0,2)+1 \\ D(1,1)+1 \\ D(0,1)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 2 \\ 2 \end{cases}$$

$$= 2.$$

3) $d \neq i$.

$\therefore$ cost = 1.

$$D(1,3) = \min \begin{cases} D(0,3)+1 \\ D(1,2)+1 \\ D(0,2)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 3 \end{cases}$$

$$= 3.$$

4) $d \neq e$.

$\therefore$ cost = 1

$$D(1,4) = \min \begin{cases} D(0,4)+1 \\ D(1,3)+1 \\ D(0,3)+1 \end{cases}$$

$$= \min \begin{cases} 5 \\ 4 \\ 4 \end{cases}$$

$$= 4.$$

5) $d \neq f$.

$\therefore$ cost = 1.

$$D(1,5) = \min \begin{cases} D(0,5)+1 \\ D(1,4)+1 \\ D(0,4)+1 \end{cases}$$

$$= \min \begin{cases} 6 \\ 5 \\ 5 \end{cases}$$

$$= 5.$$

∴ Distance grid —

		0	1	2	3	4	5
		–	b	u	i	e	f
0	–	0	1	2	3	4	5
1	d	1	1	2	3	1	5.
2	u	2					
3	i	3					
4	v	4					
5	e	5					

Row - 2 (i=2) :-

1) u ≠ b.

∴ cost = 1.

$$D(2,1) = \min \begin{cases} D(1,1)+1 \\ D(2,0)+1 \\ D(1,0)+1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 3 \\ 2 \end{cases}$$

$$= 2.$$

2) u = u.

∴ cost = 0.

$$D(2,2) = \min \begin{cases} D(1,2)+1 \\ D(2,1)+1 \\ D(1,1)+0 \end{cases}$$

$$= \min \begin{cases} 3 \\ 3 \\ 1 \end{cases} = 1.$$

3) $u \neq i$.

$\therefore$ cost = 1.

$$D(2,3) = \min \begin{cases} D(1,3)+1 \\ D(2,2)+1 \\ D(1,2)+1 \end{cases}$$

$$= \min \begin{cases} 1 \\ 2 \\ 3 \end{cases}$$

$$= 2.$$

4) $u \neq e$.

$\therefore$ cost = 1.

$$D(2,4) = \min \begin{cases} D(1,4)+1 \\ D(2,3)+1 \\ D(1,3)+1 \end{cases}$$

$$= \min \begin{cases} 5 \\ 3 \\ 4 \end{cases}$$

$$= 3.$$

5) $u \neq f$.

$\therefore$ cost = 1.

$$D(2,5) = \min \begin{cases} D(1,5)+1 \\ D(2,4)+1 \\ D(1,4)+1 \end{cases}$$

$$= \min \begin{cases} 6 \\ 4 \\ 5 \end{cases}$$

$$= 4.$$

∴ Distance guid —

		0 –	1 b	2 u	3 i	4 e	5 f
0	–	0	1	2	3	4	5
1	d	1	1	2	3	4	5
2	u	2	2	1	2	3	4
3	i	3					
4	v	4					
5	e	5					

Row-3 ($i = 3$):-

1) $i \neq b$.

∴ Cost = 1.

$$D(3,1) = \min \begin{cases} D(2,1)+1 \\ D(3,0)+1 \\ D(2,0)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 4 \\ 3 \end{cases}$$

$$= 3.$$

2) $i \neq u$.

∴ Cost = 1.

$$D(3,2) = \min \begin{cases} D(2,2)+1 \\ D(3,1)+1 \\ D(2,1)+1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 4 \\ 3 \end{cases} = 2.$$

3) $i = i$.

$\therefore cost = 0$.

$$D(3,3) = \min \begin{cases} D(2,3)+1 \\ D(3,2)+1 \\ D(2,2)+0 \end{cases}$$

$$= \min \begin{cases} 3 \\ 3 \\ 1 \end{cases}$$

$$= 1.$$

4) $i \neq e$.

$\therefore cost = 1$.

$$D(3,4) = \min \begin{cases} D(2,4)+1 \\ D(3,3)+1 \\ D(2,3)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 2 \\ 3 \end{cases}$$

$$= 2.$$

5) $i \neq f$.

$\therefore cost = 1$.

$$D(3,5) = \min \begin{cases} D(2,5)+1 \\ D(3,4)+1 \\ D(2,4)+1 \end{cases}$$

$$= \min \begin{cases} 5 \\ 3 \\ 4 \end{cases}$$

$$= 3.$$

∴ Distance grid —

		0	1	2	3	4	5
		–	b	u	i	e	f
0	–	0	1	2	3	4	5
1	d	1	1	2	3	4	5
2	u	2	2	1	2	3	4.
3	i	3	3	2	1	2	3
4	v	4					
5	e	5					

Row-4 (i=4):-

1) $v \neq b$.

∴ cost = 1.

$$D(4,1) = \min \begin{cases} D(3,1)+1 \\ D(4,0)+1 \\ D(3,0)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 5 \\ 4 \end{cases}$$

$$= 4.$$

2) $v \neq u$.

∴ cost = 1.

$$D(4,2) = \min \begin{cases} D(3,2)+1 \\ D(4,1)+1 \\ D(3,1)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 5 \\ 4 \end{cases} = 3.$$

3) $v \neq i$.

$\therefore$ Cost = 1.

$$D(4,3) = \min \begin{cases} D(3,3)+1 \\ D(4,2)+1 \\ D(3,2)+1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 4 \\ 3 \end{cases} = 2.$$

4) $v \neq e$.

$\therefore$ Cost = 1.

$$D(4,4) = \min \begin{cases} D(3,4)+1 \\ D(4,3)+1 \\ D(3,3)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 3 \\ 2 \end{cases} = 2.$$

5) $v \neq f$.

$\therefore$ Cost = 1.

$$D(4,5) = \min \begin{cases} D(3,5)+1 \\ D(4,4)+1 \\ D(3,4)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 3 \end{cases}$$

$$= 3.$$

∴ Distance grid —

		0	1	2	3	4	5
		–	b	u	i	e	f
0	–	0	1	2	3	4	5
1	d	1	1	2	3	4	5
2	u	2	2	1	2	3	4
3	i	3	3	2	1	2	3
4	v	4	4	3	2	2	3.
5	e	5					

Row-5 ($i=5$) :-

1) $e \neq b$.

∴ cost = 1.

$$D(5,1) = \min \begin{cases} D(4,1)+1 \\ D(5,0)+1 \\ D(4,0)+1 \end{cases}$$

$$= \min \begin{cases} 5 \\ 6 \\ 5 \end{cases} = 5.$$

2) $e \neq u$.

∴ cost = 1.

$$D(5,2) = \min \begin{cases} D(4,2)+1 \\ D(5,1)+1 \\ D(4,1)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 6 \\ 5 \end{cases} = 4.$$

3) $e \neq i$.

$\therefore$ cost = 1.

$$D(5,3) = \min \begin{cases} D(4,3)+1 \\ D(5,2)+1 \\ D(4,2)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 5 \\ 4 \end{cases} = 3.$$

4) $e = e$.

$\therefore$ cost = 0.

$$D(5,4) = \min \begin{cases} D(4,4)+1 \\ D(5,3)+1 \\ D(4,3)+0. \end{cases}$$

$$= \min \begin{cases} 3 \\ 4 \\ 3 \end{cases} = 3.$$

5) $e \neq f$.

$\therefore$ cost = 1.

$$D(5,5) = \min \begin{cases} D(4,5)+1 \\ D(5,4)+1 \\ D(4,4)+1. \end{cases}$$

$$= \min \begin{cases} 4 \\ 4 \\ 3 \end{cases}$$

$$= 3.$$

∴ Distance grid —

		0	1	2	3	4	5
		–	b	u	i	e	f
0	–	0	1	2	3	4	5
1	d	1	1	2	3	4	5
2	u	2	2	1	2	3	4
3	i	3	3	2	1	2	3
4	v	4	4	3	2	2	3
5	e	5	5	4	3	3	**3**

∴ The edit distance of "duive" to "buief" is 3 units.

Now, let A = "duive" = source

and, B = "divers" = target.

		0	1	2	3	4	5	6
		–	d	i	v	e	u	s
0	–	0	1	2	3	4	5	6
1	d	1						
2	u	2						
3	i	3						
4	v	4						
5	e	5						

Row-1 ($i=1$):

1) $d = d$.

$\therefore$ cost = 0.

$$D(1,1) = \min \begin{cases} D(0,1)+1 \\ D(1,0)+1 \\ D(0,0)+0 \end{cases}$$

$$= \min \begin{cases} 2 \\ 2 \\ 0 \end{cases} = 0.$$

2) $d \neq i$.

$\therefore$ cost = 1.

$$D(1,2) = \min \begin{cases} D(0,2)+1 \\ D(1,1)+1 \\ D(0,1)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 1 \\ 2 \end{cases} = 1.$$

3) $d \neq v$.

$\therefore$ cost = 1.

$$D(1,3) = \min \begin{cases} D(0,3)+1 \\ D(1,2)+1 \\ D(0,2)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 2 \\ 3 \end{cases} = 2.$$

4) d ≠ e.

∴ cost = 1.

$$D(1,4) = \min \begin{cases} D(0,4)+1 \\ D(1,3)+1 \\ D(0,3)+1 \end{cases}$$

$$= \min \begin{cases} 5 \\ 3 \\ 4 \end{cases} = 3.$$

5) d ≠ w.

∴ cost = 1

$$D(1,5) = \min \begin{cases} D(0,5)+1 \\ D(1,4)+1 \\ D(0,4)+1 \end{cases}$$

$$= \min \begin{cases} 6 \\ 4 \\ 5 \end{cases} = 4.$$

6) d ≠ l.

∴ cost = 1.

$$D(1,6) = \min \begin{cases} D(0,6)+1 \\ D(1,5)+1 \\ D(0,5)+1 \end{cases}$$

$$= \min \begin{cases} 7 \\ 5 \\ 6 \end{cases}$$

$$= 5.$$

∴ Distance grid —

		0	1	2	3	4	5	6
		–	d	i	v	e	u	l
0	–	0	1	2	3	4	5	6
1	d	1	0	1	2	3	4	5
2	u	2						
3	i	3						
4	v	4						
5	e	5						

Row-2 (i=2) :-

1) u ≠ d.

∴ cost = 1.

$$D(2,1) = \min \begin{cases} D(1,1)+1 \\ D(2,0)+1 \\ D(1,0)+1 \end{cases}$$

$$= \min \begin{cases} 1 \\ 3 \\ 2 \end{cases} = 1.$$

2) u ≠ i.

∴ cost = 1.

$$D(2,2) = \min \begin{cases} D(1,2)+1 \\ D(2,1)+1 \\ D(1,1)+1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 2 \\ 1 \end{cases} = 1.$$

3) $u \neq v$.

$\therefore$ cost = 1.

$$D(2,3) = \min \begin{cases} D(1,3)+1 \\ D(2,2)+1 \\ D(1,2)+1 \end{cases}$$

$$= \min \begin{cases} 3 \\ 2 \\ 2 \end{cases} = 2.$$

4) $u \neq e$

$\therefore$ cost = 1.

$$D(2,4) = \min \begin{cases} D(1,4)+1 \\ D(2,3)+1 \\ D(1,3)+1 \end{cases}$$

$$= \min \begin{cases} 4 \\ 3 \\ 3 \end{cases} = 3.$$

5) $u = u$.

$\therefore$ cost = 0.

$$D(2,5) = \min \begin{cases} D(1,5)+1 \\ D(2,4)+1 \\ D(1,4)+0 \end{cases}$$

$$= \min \begin{cases} 5 \\ 4 \\ 3 \end{cases} = 3$$

6) $u \neq s$.

$\therefore$ cost = 1.

$$D(2,6) = \min \begin{cases} D(1,6)+1 \\ D(2,5)+1 \\ D(1,5)+1 \end{cases} = \min \begin{cases} 6 \\ 4 \\ 5 \end{cases} = 4$$

∴ Distance grid —

		0	1	2	3	4	5	6
		–	d	i	v	e	u	s
0	–	0	1	2	3	4	5	6
1	d	1	0	1	2	3	4	5
2	u	2	1	1	2	3	3	4
3	i	3						
4	v	4						
5	e	5						

Row-3 (i=3):-

1) i ≠ d.

∴ cost = 1.

$$D(3,1) = \min \begin{cases} D(2,1)+1 \\ D(3,0)+1 \\ D(2,0)+1 \end{cases} = \min \begin{cases} 2 \\ 4 \\ 3 \end{cases} = 2.$$

2) i = i.

∴ cost = 0.

$$D(3,2) = \min \begin{cases} D(2,2)+1 \\ D(3,1)+1 \\ D(2,1)+0 \end{cases} = \min \begin{cases} 2 \\ 3 \\ 1 \end{cases} = 1$$

3) i ≠ v.

∴ cost = 1

$$D(3,3) = \min \begin{cases} D(2,3)+1 \\ D(3,2)+1 \\ D(2,2)+1 \end{cases} = \min \begin{cases} 3 \\ 2 \\ 2 \end{cases} = 2$$

4) i ≠ e.

∴ cost = 1.

$$D(3,4) = \min \begin{cases} D(2,4)+1 \\ D(3,3)+1 \\ D(2,3)+1 \end{cases} = \min \begin{cases} 4 \\ 3 \\ 3 \end{cases} = 3.$$

5) i ≠ u.

∴ cost = 1.

$$D(3,5) = \min \begin{cases} D(2,5)+1 \\ D(3,4)+1 \\ D(2,4)+1. \end{cases} = \min \begin{cases} 4 \\ 4 \\ 4 \end{cases} = 4.$$

6) i ≠ l.

∴ cost = 1.

$$D(3,6) = \min \begin{cases} D(2,6)+1 \\ D(3,5)+1 \\ D(2,5)+1 \end{cases} = \min \begin{cases} 5 \\ 5 \\ 4 \end{cases} = 4.$$

∴ Distance grid —

		0	1	2	3	4	5	6
		–	d	i	v	e	u	l
0	–	0	1	2	3	4	5	6
1	d	1	0	1	2	3	4	5
2	u	2	1	1	2	3	3	4
3	i	3	2	1	2	3	4	4
4	v	4						
5	e	5						

Row-4 (i = 4) :-

1) v ≠ d.

∴ cost = 1.

$$D(4,1) = \min \begin{cases} D(3,1)+1 \\ D(4,0)+1. \\ D(3,0)+1 \end{cases} = \min \begin{cases} 3 \\ 5 \\ 4 \end{cases} = 3$$

2) $v \neq i$.

$\therefore$ cost = 1.

$$D(4,2) = \min \begin{cases} D(3,2)+1 \\ D(4,1)+1 \\ D(3,1)+1 \end{cases}$$

$$= \min \begin{cases} 2 \\ 4 \\ 3 \end{cases} = 2.$$

3) $v = v$.

$\therefore$ cost = 0.

$$D(4,3) = \min \begin{cases} D(3,3)+1 \\ D(4,2)+1 \\ D(3,2)+0 \end{cases} = \min \begin{cases} 3 \\ 3 \\ 1 \end{cases} = 1$$

4) $v \neq e$.

$\therefore$ cost = 1.

$$D(4,4) = \min \begin{cases} D(3,4)+1 \\ D(4,3)+1 \\ D(3,3)+1 \end{cases} = \min \begin{cases} 4 \\ 2 \\ 3 \end{cases} = 2$$

5) $v \neq u$.

$\therefore$ cost = 1.

$$D(4,5) = \min \begin{cases} D(3,5)+1 \\ D(4,4)+1 \\ D(3,4)+1 \end{cases} = \min \begin{cases} 5 \\ 3 \\ 4 \end{cases} = 3.$$

6) $v \neq s$.

$\therefore$ cost = 1.

$$D(4,6) = \min \begin{cases} D(3,6)+1 \\ D(4,5)+1 \\ D(3,5)+1 \end{cases} = \min \begin{cases} 6 \\ 4 \\ 5 \end{cases} = 4$$

		0	1	2	3	4	5	6
		–	d	i	v	e	u	l
0	–	0	1	2	3	4	5	6
1	d	1	0	1	2	3	4	5
2	u	2	1	1	2	3	3	4
3	i	3	2	1	2	3	4	4
4	v	4	3	2	1	2	3	4.
5	e	5						

Row-5 ($i = 5$):-

1) $e \neq d$.

$\therefore$ cost = 1.

$$D(5,1) = \min \begin{cases} D(4,1)+1 \\ D(5,0)+1 \\ D(4,0)+1 \end{cases} = \min \begin{cases} 4 \\ 6 \\ 5 \end{cases} = 4.$$

2) $e \neq i$.

$\therefore$ cost = 1.

$$D(5,2) = \min \begin{cases} D(4,2)+1 \\ D(5,1)+1 \\ D(4,1)+1 \end{cases} = \min \begin{cases} 3 \\ 5 \\ 4 \end{cases} = 3$$

3) $e \neq v$.

$\therefore$ cost = 1.

$$D(5,3) = \min \begin{cases} D(4,3)+1 \\ D(5,2)+1 \\ D(4,2)+1 \end{cases} = \min \begin{cases} 2 \\ 4 \\ 3 \end{cases} = 2$$

4) $e = e$.

$\therefore$ cost = 0.

$$D(5,4) = \min \begin{cases} D(4,4)+1 \\ D(5,3)+1 \\ D(4,3)+0 \end{cases} = \min \begin{cases} 1 \\ 3 \\ 1 \end{cases} = 1.$$

5) $e \neq u$.

$\therefore$ cost = 1.

$$D(5,5) = \min \begin{cases} D(4,5)+1 \\ D(5,4)+1 \\ D(4,4)+1 \end{cases} = \min \begin{cases} 4 \\ 2 \\ 3 \end{cases} = 2$$

6) $e \neq s$.

$\therefore$ cost = 1.

$$D(5,6) = \min \begin{cases} D(4,6)+1 \\ D(5,5)+1 \\ D(4,5)+1 \end{cases} = \min \begin{cases} 5 \\ 3 \\ 4. \end{cases} = 3$$

$\therefore$ Distance guid :

		0	1	2	3	4	5	6
		–	d	i	v	e	u	s
0	–	0	1	2	3	4	5	6
1	d	1	0	1	2	3	4	5
2	u	2	1	1	2	3	3	4
3	i	3	2	1	2	3	4	4
5	v	4	3	2	1	2	3	4
6	e	5	4	3	2	1	2	3.

$\therefore$ The edit distance of "drive" to "diveus" is 3 units.

$\therefore$ "drive" is equally distant to "buief" and "diveus".