# INF281 Exercise 02 solutions

# 1. DP table cell update rules

Dynamic programming (DP) is an algorithm that uses table cells to memorize the subsolutions of the target solution. DP requires three candidate scores and selects the maximum score among them when updating a cell.

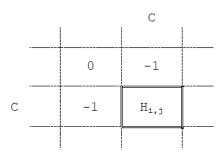
$$H_{i,j}^{(0)} = H_{i-1,j} - g$$
 (vertical)  
 $H_{i,j}^{(1)} = H_{i,j-1} - g$  (horizontal)  
 $H_{i,j}^{(2)} = H_{i-1,j-1} + R_{a,b}$  (diagonal)

Use the simple scoring scheme below to calcualte  $H_{i,j}$  in Table A and B.

# Scoring scheme:

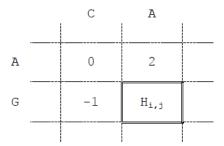
$$R_{ab} = 1$$
 for  $a = b$   
 $R_{ab} = 0$  for  $a \neq b$   
 $g = 1$ 

(a) Table A



# Solution: 1

# (b) Table B



#### Solution: 1

### 2. **DP** initialization

Initialization is the first step of the DP procedures.

(a) Initialize the DP table with gap penalty 3.

q\d		С	A	Т
	0	-3	-6	-9
С	-3			
A	-6			

# 3. DP global alignment

The score of optimal global alignment is found in the cell of the bottom-right corner after updating all cells.

### Scoring scheme:

$$R_{ab} = 1$$
 for  $a = b$   
 $R_{ab} = 0$  for  $a \neq b$   
 $g = 1$ 

(a) Use the simple scorning scheme and fill the empty cells with appropriate scores.

q\d		С	A	Т
	0	-1	-2	-3
С	-1	1	0	-1
A	-2	0	2	1
G	-3	-1	1	2
С	-4	-2	0	1
Т	-5	-3	-1	1

(b) What is the optimal score of the alignemnt?

Solution: 1

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#### 4. DP backtrack

Backtracking is a process to find the alignment with the optical score. It requires recalculations of the three candidate scores.

Scoring scheme:

$$R_{ab} = 1$$
 for  $a = b$   
 $R_{ab} = 0$  for  $a \neq b$   
 $g = 1$ 

- (a) Which type of candidate score vertical, horizontal, or diagonal is used to update the cell with a double border? Assume that the simple scoring scheme has been used.
  - Table 1

	C	A	
A	0	2	
G	-1	1	

#### Solution: Vertical

• Table 2

	A	Т	
С	0	1	
Т	-1	1	

# Solution: Diagonal

(b) Use backtracking to find the optimal global alignment.

q\d		С	A	Т
	0	-1	-2	-3
С	-1	1	0	-1
A	-2	0	2	1

#### **Solution:**

q: CA-

d: CAT

#### 5. DP with score matrix

Use the score matrix below with gap penalty g = 1 and answer the following questions.

	С	G	Α	Т
C	1	0	0	0
G		1	1	0
Α			1	0
Τ				1

- (a) Calculate the alignment score.
  - Alignment 1

q: ATGCT d: CA--T

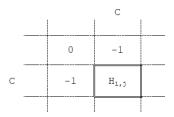
# Solution: -1

• Alignment 2

q: CAGCT d: C-A-T

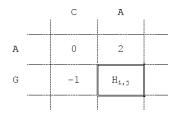
### Solution: 1

- (b) Calculate the score of  $H_{i,j}$ .
  - Table A



### Solution: 1

• Table B



# Solution: 1

(c) Fill the empty cells with appropriate scores in the DP table. What is the optimal alignment score?

q\d		С	A	Т
	0	-1	-2	-3
С	-1	1	0	-1
A	-2	0	2	1
G	-3	-1	1	2
С	-4	-2	0	1
Т	-5	-3	-1	1

# Solution: 1

(d) There are two different alignments that give the same optimal score in the solution above. Specify both of them.

### **Solution:**

q: CAGCT

d: CA--T

q: CAGCT

d: C-A-T