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Date:	**3 Oct 2014**
Title:	**GNBF5010 assignment 1**

1) Several ways to write Fibonacci series in C language
    i. For loop

```
#include<stdio.h>
int main()
{
    int n, first = 0, second = 1, next, c;
    printf("Enter the number of terms\n");
    scanf("%d",&n);
    printf("First %d terms of Fibonacci series are :-\n",n);
    for ( c = 0 ; c < n ; c++ )
    {
        if ( c <= 1 )
            next = c;
        else
        {
            next = first + second;
            first = second;
            second = next;
        }
        printf("%d\n",next);
    }
    return 0;
}
```

    ii. Recursive function

```
#include<stdio.h>
int Fibonacci(int);
main()
{
    int n, i = 0, c;
      printf("Enter the number of terms\n");
      scanf("%d",&n);
        printf("First %d terms of Fibonacci series are :-\n",n);
    for ( c = 1 ; c <= n ; c++ )
```

```
      {
            printf("%d\n", Fibonacci(i));
            i++;
      }
  return 0;
}
  int Fibonacci(int n)
{
      if ( n == 0 )
            return 0;
      else if ( n == 1 )
            return 1;
      else
            return ( Fibonacci(n-1) + Fibonacci(n-2) );
}
```

iii. Dynamic programming

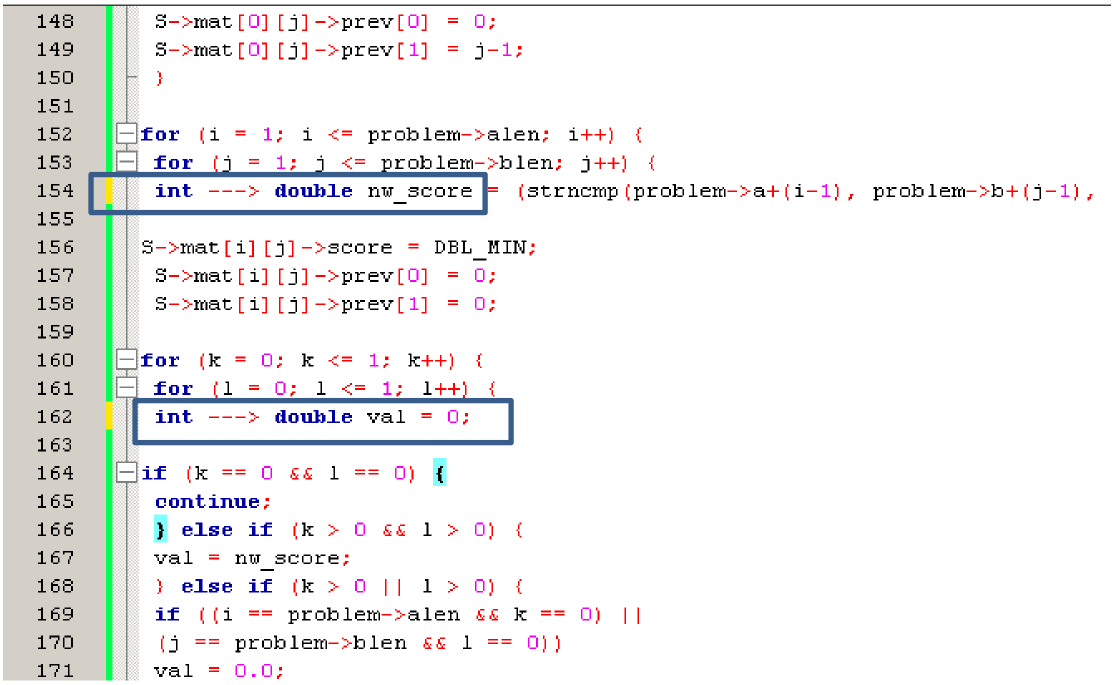
```
int fib(int n)
{
/* Declare an array to store fibonacci numbers. */
int f[n+1];
int i;
/* 0th and 1st number of the series are 0 and 1*/
f[0] = 0;
f[1] = 1;
for (i = 2; i <= n; i++)
{
/* Add the previous 2 numbers in the series
and store it */
f[i] = f[i-1] + f[i-2];
}
return f[n];
}
int main ()
{int n,c,j=0;
printf("Enter the number of terms\n");
scanf("%d",&n);
printf("First %d terms of Fibonacci series are :-\n",n);
      for ( c = 1 ; c <= n ; c++ )
      {
        printf("%d\n", fib(j));
        j++;
    }

getchar();
return 0;
}
```

Performance

Methodology	10 nos	40 nos	160 nos	640 nos
For loop	2.512s	2.761s	2.824s	3.079s
Recursive function	2.695s	3.954s	>60s	>60s
Dynamic programming	2.476s	2.749s	2.960s	4.720s

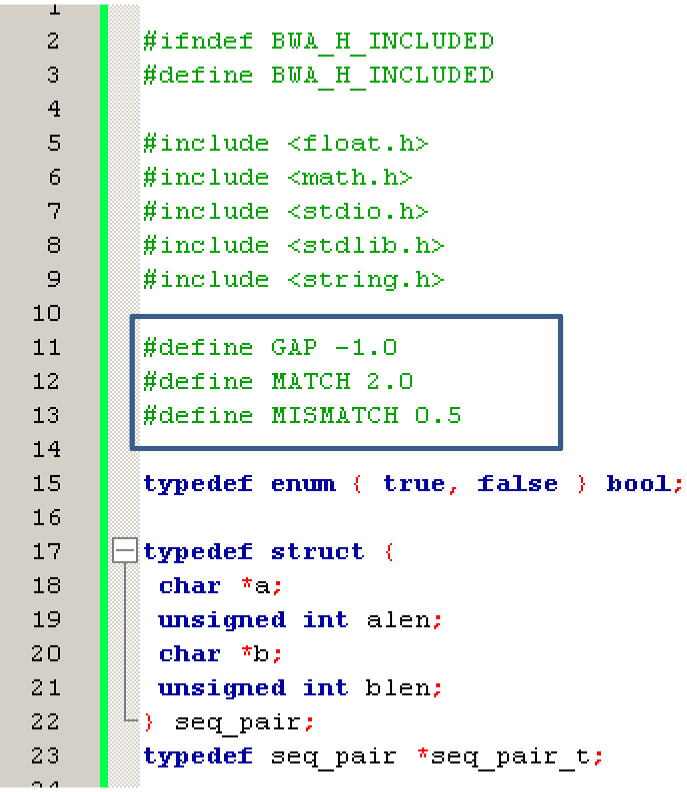
2)

In file swa.c line 154 & 162 amend data type from integer to double thus to adopt mismatch score with 0.5.



```
148     S->mat[0][j]->prev[0] = 0;
149     S->mat[0][j]->prev[1] = j-1;
150     }
151
152   for (i = 1; i <= problem->alen; i++) {
153     for (j = 1; j <= problem->blen; j++) {
154     int ---> double nw_score = (strncmp(problem->a+(i-1), problem->b+(j-1),
155
156   S->mat[i][j]->score = DBL_MIN;
157     S->mat[i][j]->prev[0] = 0;
158     S->mat[i][j]->prev[1] = 0;
159
160   for (k = 0; k <= 1; k++) {
161     for (l = 0; l <= 1; l++) {
162     int ---> double val = 0;
163
164   if (k == 0 && l == 0) {
165     continue;
166     } else if (k > 0 && l > 0) {
167     val = nw_score;
168     } else if (k > 0 || l > 0) {
169     if ((i == problem->alen && k == 0) ||
170     (j == problem->blen && l == 0))
171     val = 0.0;
```

In swa.h file line 11, 12 and 13 amend the score as in the question as -1.0, 2.0 and 0.5.

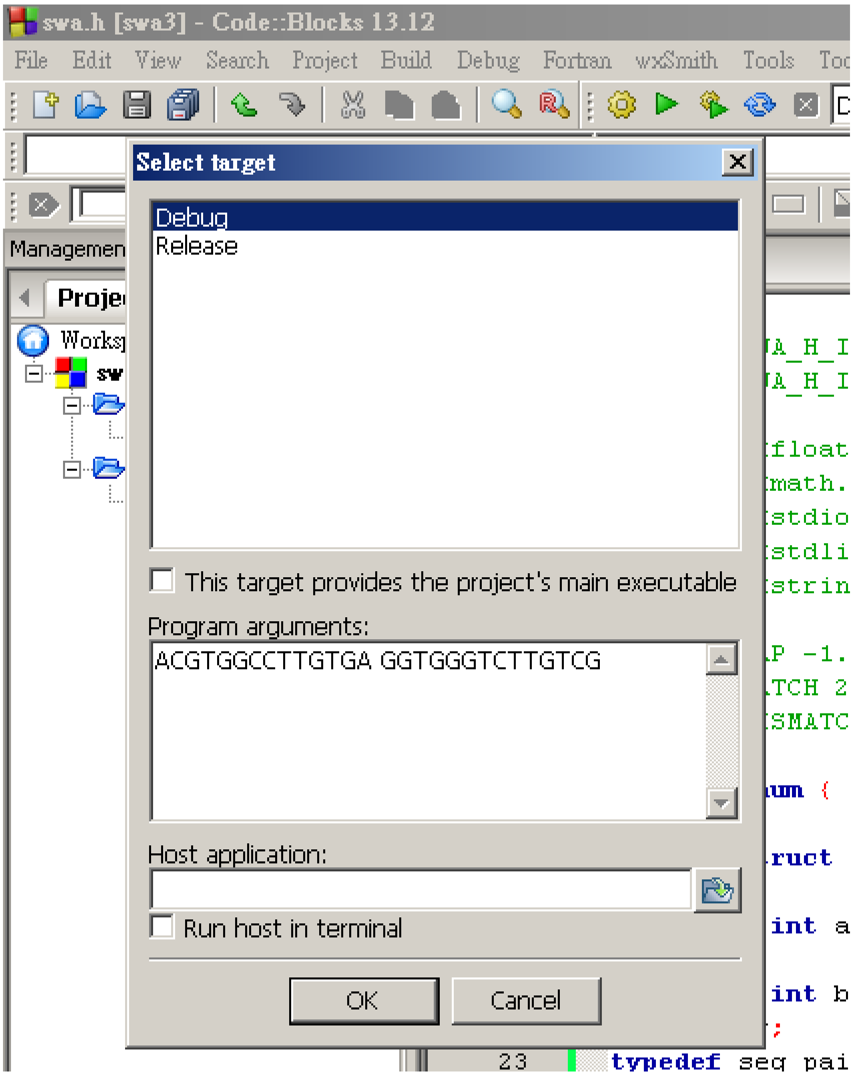


```
1
2   #ifndef BWA_H_INCLUDED
3   #define BWA_H_INCLUDED
4
5   #include <float.h>
6   #include <math.h>
7   #include <stdio.h>
8   #include <stdlib.h>
9   #include <string.h>
10
11  #define GAP -1.0
12  #define MATCH 2.0
13  #define MISMATCH 0.5
14
15  typedef enum { true, false } bool;
16
17  typedef struct {
18    char *a;
19    unsigned int alen;
20    char *b;
21    unsigned int blen;
22  } seq_pair;
23  typedef seq_pair *seq_pair_t;
```

U

Set argument in Code::blocks by select project>Set project’s argument.

Input the sequences.


swa.h [swa3] - Code::Blocks 13.12
File Edit View Search Project Build Debug Fortran wxSmith Tools
Management
Projects
Workspace
OK
Cancel

Select target

Debug
Release

□ This target provides the project's main executable

Program arguments:

ACGTGGCCTTGTGA GGTGGGTCTTGTCG

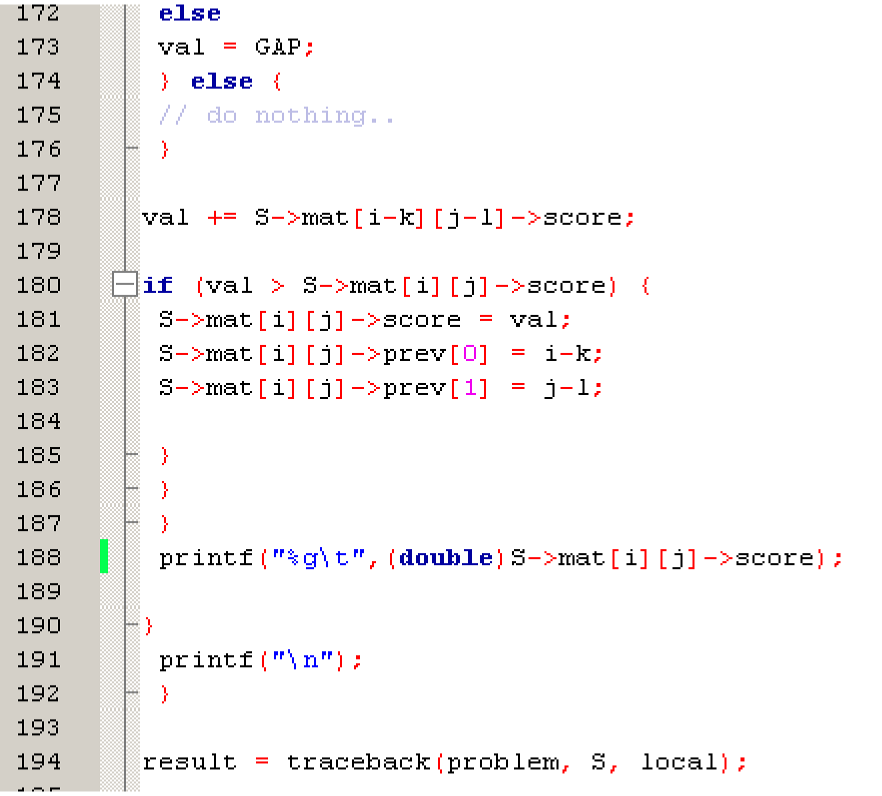
Host application:

□ Run host in terminal

Go to build and run

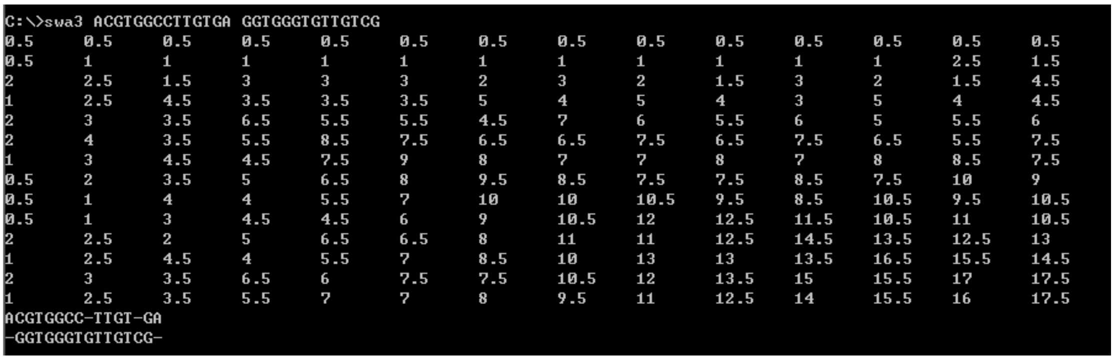
```
A  C  G  T  G  G  C  -  C  T  T  G  T  -  G  A
-  G  G  T  G  G  G  T  C  T  T  G  T  C  G  -

Process returned 0 (0x0)   execution time : 0.033 s
```

To provide decimal display in the matrix, change line 188 “%d” to “%g” and “int” to “double” so as to store and display decimal instead of integer .



```
172      else
173      val = GAP;
174      } else {
175      // do nothing..
176      }
177
178     val += S->mat[i-k][j-l]->score;
179
180     if (val > S->mat[i][j]->score) {
181      S->mat[i][j]->score = val;
182      S->mat[i][j]->prev[0] = i-k;
183      S->mat[i][j]->prev[1] = j-l;
184
185      }
186      }
187      }
188      printf("%g\t",(double)S->mat[i][j]->score);
189
190     }
191      printf("\n");
192      }
193
194     result = traceback(problem, S, local);
```

In command console, input “mode 120,50” to expand column size and run swa.exe with argument “ACGTGGCCTTGTGA” and “GGTGGGTGTTGTCG”.



```
C:\>swa3 ACGTGGCCTTGTGA GGTGGGTGTTGTCG
0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.5
0.5     1       1       1       1       1       1       1       1       1       1       1       2.5     1.5
2       2.5     1.5     3       3       3       2       3       2       1.5     3       2       1.5     4.5
1       2.5     4.5     3.5     3.5     3.5     5       4       5       4       3       5       4       4.5
2       3       3.5     6.5     5.5     5.5     4.5     7       6       5.5     6       5       5.5     6
2       4       3.5     5.5     8.5     7.5     6.5     6.5     7.5     6.5     7.5     6.5     5.5     7.5
1       3       4.5     4.5     7.5     9       8       7       7       8       7       8       8.5     7.5
0.5     2       3.5     5       6.5     8       9.5     8.5     7.5     7.5     8.5     7.5     10      9
0.5     1       4       4       5.5     7       10      10      10.5    9.5     8.5     10.5    9.5     10.5
0.5     1       3       4.5     4.5     6       9       10.5    12      12.5    11.5    10.5    11      10.5
2       2.5     2       5       6.5     6.5     8       11      11      12.5    14.5    13.5    12.5    13
1       2.5     4.5     4       5.5     7       8.5     10      13      13      13.5    16.5    15.5    14.5
2       3       3.5     6.5     6       7.5     7.5     10.5    12      13.5    15      15.5    17      17.5
1       2.5     3.5     5.5     7       7       8       9.5     11      12.5    14      15.5    16      17.5
ACGTGGCC-TTGT-GA
-GGTGGGTGTTGTCG-
```

Source code as following: amended code is in red

swa.c

```
#include "swa3.h"

/* reverse a string in place, return str */
static char* reverse(char *str) {
  char *left = str;
  char *right = left + strlen(str) - 1;
  char tmp;

while (left < right) {
  tmp = *left;
  *(left++) = *right;
  *(right--) = tmp;
  }

return str;
}

// works globally
static seq_pair_t traceback(seq_pair_t problem, matrix_t S, bool local) {
  seq_pair_t result = malloc(sizeof(seq_pair));
  unsigned int i = S->m - 1;
  unsigned int j = S->n - 1;
  unsigned int k = 0;
  char c[S->m + S->n + 1];
  char d[S->m + S->n + 1];

memset(c, '\0', sizeof(c));
  memset(d, '\0', sizeof(d));

if (local == true) {
  unsigned int l, m;
  double max = FLT_MIN;

for (l = 0; l < S->m; l++) {
  for (m = 0; m < S->m; m++) {
  if (S->mat[l][m]->score > max) {
  i = l;
  j = m;
  }
  }
  }
  }

if (S->mat[i][j]->prev[0] != 0 && S->mat[i][j]->prev[1] != 0) {
  while (i > 0 || j > 0) {
  unsigned int new_i = S->mat[i][j]->prev[0];
  unsigned int new_j = S->mat[i][j]->prev[1];

  if (new_i < i)
  *(c+k) = *(problem->a+i-1);
  else
  *(c+k) = '-';

  if (new_j < j)
  *(d+k) = *(problem->b+j-1);
  else
  *(d+k) = '-';

  k++;

  i = new_i;
  j = new_j;
  }
  }

result->a = malloc(sizeof(char) * k + 1);
  result->b = malloc(sizeof(char) * k + 1);

memset(result->a, '\0', sizeof(*result->a));
memset(result->b, '\0', sizeof(*result->b));

reverse(c);
  reverse(d);

strcpy(result->a, c);
  strcpy(result->b, d);

result->alen = k;
  result->blen = k;

return result;
```

```
}

static matrix_t create_matrix(unsigned int m, unsigned int n) {
  matrix_t S = malloc(sizeof(matrix));
  unsigned int i, j;

S->m = m;
  S->n = n;

S->mat = malloc(sizeof(entry_t) * m * n);

for (i = 0; i < m; i++) {
  S->mat[i] = malloc(sizeof(entry_t) * n);
  }

for (i = 0; i < m; i++) {
  for (j = 0; j < n; j++) {
  S->mat[i][j] = malloc(sizeof(entry));
  }
  }

return S;
}

void destroy_matrix(matrix_t S) {
  unsigned int i, j;

for (i = 0; i < S->m; i++) {
  for (j = 0; j < S->n; j++) {
  free(S->mat[i][j]);
  }
  }

free(S);

return;
}

void destroy_seq_pair(seq_pair_t pair) {
  free(pair->a);
  free(pair->b);
free(pair);

return;
}

static seq_pair_t smith_waterman(seq_pair_t problem, bool local) {
  unsigned int m = problem->alen + 1;
  unsigned int n = problem->blen + 1;
  matrix_t S = create_matrix(m, n);
  seq_pair_t result;
  unsigned int i, j, k, l;

S->mat[0][0]->score = 0;
  S->mat[0][0]->prev[0] = 0;
  S->mat[0][0]->prev[1] = 0;

for (i = 1; i <= problem->alen; i++) {
  S->mat[i][0]->score = 0.0;
  S->mat[i][0]->prev[0] = i-1;
  S->mat[i][0]->prev[1] = 0;
  }

for (j = 1; j <= problem->blen; j++) {
  S->mat[0][j]->score = 0.0;
  S->mat[0][j]->prev[0] = 0;
  S->mat[0][j]->prev[1] = j-1;
  }

for (i = 1; i <= problem->alen; i++) {
  for (j = 1; j <= problem->blen; j++) {
  double nw_score = (strncmp(problem->a+(i-1), problem->b+(j-1), 1) == 0) ? MATCH : MISMATCH;

S->mat[i][j]->score = DBL_MIN;
  S->mat[i][j]->prev[0] = 0;
  S->mat[i][j]->prev[1] = 0;

for (k = 0; k <= 1; k++) {
  for (l = 0; l <= 1; l++) {
  double val = 0;

if (k == 0 && l == 0) {
  continue;
```

```
 } else if (k > 0 && l > 0) {
 val = nw_score;
 } else if (k > 0 || l > 0) {
 if ((i == problem->alen && k == 0) ||
 (j == problem->blen && l == 0))
 val = 0.0;
 else
 val = GAP;
 } else {
 // do nothing..
 }

val += S->mat[i-k][j-l]->score;

if (val > S->mat[i][j]->score) {
 S->mat[i][j]->score = val;
 S->mat[i][j]->prev[0] = i-k;
 S->mat[i][j]->prev[1] = j-l;

 }
 }
 }
 printf("%g\t",(double)S->mat[i][j]->score);

}
 printf("\n");
 }

result = traceback(problem, S, local);

destroy_matrix(S);

return result;
}

int main(int argc, const char **argv) {



if (argc != 3) {
 printf("Wrong Input Format!!!!!!!\nEnter ./a.out SEQ1 SEQ2\n");
 exit(1);
```

```
  }

{
  seq_pair problem;
  seq_pair_t result;
  char c[strlen(argv[1])], d[strlen(argv[2])];

  strcpy(c, argv[1]);
  strcpy(d, argv[2]);

  problem.a = c;
  problem.alen = strlen(problem.a);
  problem.b = d;
  problem.blen = strlen(problem.b);

  result = smith_waterman(&problem, false);

  printf("%s\n%s\n", result->a, result->b);
  }

exit(0);
}
```

swa.h

```
#ifndef BWA_H_INCLUDED
#define BWA_H_INCLUDED

#include <float.h>
#include <math.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define GAP -1.0
#define MATCH 2.0
#define MISMATCH 0.5

typedef enum { true, false } bool;
typedef struct {
  char *a;
  unsigned int alen;
  char *b;
  unsigned int blen;
} seq_pair;
typedef seq_pair *seq_pair_t;

typedef struct {
  double score;
  unsigned int prev[2];
} entry;
typedef entry *entry_t;

typedef struct {
  unsigned int m;
  unsigned int n;
  entry_t **mat;
} matrix;
typedef matrix *matrix_t;

static char* reverse(char *str);

static seq_pair_t traceback(seq_pair_t problem, matrix_t S, bool local);

static matrix_t create_matrix(unsigned int m, unsigned int n);

void destroy_matrix(matrix_t S);

void destroy_seq_pair(seq_pair_t pair);

static seq_pair_t smith_waterman(seq_pair_t problem, bool local);

#endif // BWA_H_INCLUDED
```

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GNBF5010	Introduction to programming
Course code	Course title