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Übungen zur Vorlesung Informatik II (D-BAUG) FS 2017

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http://lec.inf.ethz.ch/baug/informatik2/2017

Solution to exercise sheet # 3 **6.3.2017 – 14.3.2017**

Problem 3.1. Reverse Words

Open the task description here: https://codeboard.ethz.ch/inf2baugex03t01. In this task you write a program that takes strings as an input and reverses the order of the character in the strings. For instance for the input string `Hello` the program returns the string `olleH`.

Looking at the `main` function in Main.java, you can see that it reads a string from the input and then it checks if this string is equal to "exit". If this is the case the program prints out "exit." and terminates. Otherwise the program is going to reverse the characters in the string and output it. After reversing a string the program goes back to the beginning of the `while` loop and reads in the next string. This means the program will read in new string until you enter "exit".

```
Scanner input = new Scanner (System.in);
while (true) {
    String str = input.next();
    if (str.equals("exit")) {
        System.out.println("exit.");
        break;
    }
    //TODO reverse the input string str and print it out
}
```

Implement the functionality to reverse the string, you can make use of the java function `charAt(int pos)` to get the character at position `pos` in a string.

You can test your program by un-commenting the annotation `@RunTests`. Once you pass the test you can submit your program.

Solution of Problem 3.1.

```
/**
 * Main class of the Java program.
 *
 * For TESTING and SUBMITTING: Uncomment the @RunTests annotation
 * (Remove the two slashes at the beginning of line ~10)
 */
import java.util.Scanner;

@RunTests
public class Main {
        public static void main(String[] args) {
            Scanner input = new Scanner (System.in);
            while (true) {
            String str = input.next();
            if (str.equals("exit")) {
                System.out.println("exit.");
                break;
            }
            String rev = "";
            for (int i = str.length()-1; i >= 0; i--) {
                rev += str.charAt(i);
            }
            System.out.println(rev);
            }
        }
}
```

Problem 3.2. Matrix Multiplication

Open the task description here: https://codeboard.ethz.ch/inf2baugex03t02. In this task you are implementing two functions, the first one `readMatrix` reads a matrix from the input, the second one `multiplyMatrix` multiplies two matrices and returns the resulting matrix.

First have a look at the function `readMatrix` in the file Main.java. In order to read a matrix from the input use the Scanner. The format of a $r \times c$ matrix is explained with the following 2×3 example matrix:

```
2 3
0.10000 0.20000 0.30000
1.10000 1.20000 1.30000
```

The first line contains the number r of rows followed by the number c of columns, both integers. The following r lines contain c doubles each, representing a $r \times c$ matrix. The numbers are separated by whitespaces.

After implementing this function you can complete the implementation of the `multiplyMatrix` function. The goal is to do a matrix multiplication $(m1 \times m2)$, where $m1$ has size $(N1 \times M1)$ and $m2$ has size $(N2 \times M2)$ and $N1, M1, N2, M2 > 0$. The resulting matrix should be of size $(N1 \times M2)$. Do not modify the input data.

After implementing the function you can test your program by un-commenting the annotation `@RunTests`. Once you pass the test you can submit your program.

Solution of Problem 3.2.

```java
/**
 * Main class of the Java program.
 *
 * For TESTING and SUBMITTING: Uncomment the @RunTests annotation
 * (Remove the two slashes at the beginning of line ~10)
 *
 */
import java.util.Scanner;

@RunTests
public class Main {

    // pre: non-empty matrix m
    // post: matrix printout on System.out
    public static void printMatrix(double[][] m) {
        int rows = m.length;
        int cols = m[0].length;
        System.out.println(rows + " " + cols);
        for (int r = 0; r < rows; r++) {
            for (int c = 0; c < cols; c++) {
                System.out.printf("%7.1f ", m[r][c]);
            }
            System.out.printf("\n");
        }
    }

    // pre: matrix data provided via scanner
```

```java
// post: returns matrix data
public static double[][] readMatrix(Scanner scanner) {
    int M = scanner.nextInt(); // Zeilen
    int N = scanner.nextInt(); // Spalten
    // Daten
    double[][] p = new double[M][N];
    for (int i = 0; i < M; i++) {
        for (int j = 0; j < N; j++) {
            p[i][j] = scanner.nextDouble();
        }
    }
    return p;
}

// pre: non-empty input matrices m1 and m2, m1 of size N1 times M1, m2 of
    size N2 times M2
// post: return matrix product m1 * m2 in a matrix of size N1 times M2
public static double[][] multiplyMatrix(double[][] m1, double[][] m2) {
    int m1Row = m1.length;
    int m1Col = m1[0].length;
    int m2Row = m2.length;
    int m2Col = m2[0].length;

    double[][] res = new double[m1Row][m2Col];

    //Initialize with zero
    for (int i = 0; i < m1Row; i++) {
        for (int j = 0; j < m2Col; j++) {
            res[i][j] = 0;
        }
    }

    //Matrix multiplication
    for (int i = 0; i < m1Row; i++) { //m1 row
        for (int j = 0; j < m2Col; j++) { //m2 column
            for (int k = 0; k < m1Col; k++) { //m1 column
                res[i][j] += m1[i][k] * m2[k][j];
            }
        }
    }
    return res;
}

public static void main(String[] args) {
    Scanner input = new Scanner (System.in);
    // Read in m1
    double[][] matrix1 = readMatrix(input);
    // Print m1 to check if correctly read in
    System.out.println("m1:");
    printMatrix(matrix1);
    // Read in m2
    double[][] matrix2 = readMatrix(input);
    // Print m2 to check if correctly read in
    System.out.println("m2:");
```

```
        printMatrix(matrix2);
        // Multiply m1 and m2
        double[][] result = multiplyMatrix(matrix1, matrix2);
        // Print result of m1 * m2
        System.out.println("m1 * m2:");
        printMatrix(result);
    }
}
```

Problem 3.3. Artificial Words

Open the task description here: https://codeboard.ethz.ch/inf2baugex03t03.

Goal of this task is to generate artificial words from an alphabet. We consider the alphabet $\Omega = \{\text{'\_'}, \text{'A'}, \ldots, \text{'Z'}\}$. '_' stands for the empty letter.

From a very long text, for each letter $x \in \Omega$ the relative frequency of all potentially following letters $y \in \Omega$ is determined as P_{xy}. This yields a probability matrix $(P_{xy})_{x,y\in\Omega}$. Thus, P contains the relative frequencies for character combinations of the form "AA", "ST", or "_A" (empty letter before: word starts) or "Z_" (empty letter after: word ends).

Now, from the probability matrix P a word can be generated by starting with the empty letter, $x =$ '_', and subsequently drawing new characters from $P_{x\cdot}$ until the empty letter appears again.

In the following you see an excerpt of a probability matrix P, generated from a tale from Johann Wolfgang von Goethe and some generated words.

	'_'	'A'	'B'	'C'	'D'	'E'	'F'	'G'	'H'	···
'_'	0.000	0.073	0.040	0.000	0.154	0.063	0.028	0.047	0.045	···
'A'	0.008	0.002	0.049	0.048	0.006	0.000	0.011	0.047	0.031	···
'B'	0.061	0.061	0.000	0.001	0.000	0.536	0.001	0.015	0.004	···
'C'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0902	···
'D'	0.208	0.088	0.000	0.004	0.000	0.431	0.000	0.000	0.000	···
'E'	0.240	0.000	0.014	0.005	0.012	0.001	0.009	0.015	0.022	···
'F'	0.204	0.052	0.000	0.000	0.000	0.167	0.045	0.014	0.039	···
'G'	0.174	0.027	0.000	0.000	0.002	0.514	0.003	0.001	0.000	···
'H'	0.222	0.078	0.001	0.001	0.002	0.165	0.002	0.001	0.003	···
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	

```
WOPT DEDERUTERM SCHRCHLAGEGOR DIN ASTE FOSITEMER IGTES AUF SENNER DEIMER EMAR ZTENNALENDIN
WAHWAUR VOCHENS WRINGENE DESTRN ZERERTER ALISCHRDERCH IGSSONSCH VOLIGET ALZUNSCHR
LDULE AUNN UN WABGEIE D BR KENUNEIGT SPTCHIHMERR OLICHN DE SORBEN UESERER
```

In the file Main.java you see three functions: `Sample`, `GenerateWord`, and `GetMatrix`. You have to complete the first two functions. The `Sample` function returns the index of the next letter where the index is in the range 0-26. In the function `GenerateWord` you only need to complete one line. The function `GetMatrix` is already implemented. It reads the probability matrix from the file "probabilities.txt". Do not change this function nor the probabilities in the file.

Once you have implemented the two functions, you can test your program by un-commenting the annotation `@RunTests`. Once you pass the test you can submit your program.

Solution of Problem 3.3.

```
/**
 * Main class of the Java program.
 *
 * For TESTING and SUBMITTING: Uncomment the @RunTests annotation
 * (Remove the two slashes at the beginning of line ~12)
 *
 */
import java.util.Scanner;
import java.io.File;
import java.util.Random;

@RunTests
public class Main {

    // 27 characters, first letter considered empty
    final static String Letters=" ABCDEFGHIJKLMNOPQRSTUVWXYZ";
    final static Random generator = new Random(7);

    // Sample from the probabilitiy vector prob: return an index i from
    // 0 .. prob.length-1 with probability prob[i]
    // pre: prob != null, prob.length > 0
    static int Sample(double prob[]){
        double ran = generator.nextDouble(); // returns a random value in [0,1)
        //TODO implement
        double sum = prob[0];
        int x = 0;
        while (x < prob.length-1 && sum < ran){
                ++x;
                sum += prob[x];
        }
        return x;
    }

    // Generate a new word from the transition (probability) matrix M
    // Starting from index 0 sample until index is again 0, output each character
    static void GenerateWord(double M[][]){
        int letter = 0;
        do{
            //TODO implement
                letter = Sample(M[letter]);
                if (letter != 0) {
                        System.out.print(Letters.charAt(letter));
                }
        } while (letter != 0);
        System.out.println();
    }

    // This function reads the probability matrix from the file probabilities.txt
    // DO NOT CHANGE IT
    static double[][] GetMatrix(){
        double P[][] = new double[27][27];
        try {
```

```
            File file = new File("./Root/probabilities.txt");
            Scanner sc = new Scanner(file);
                for (int i = 0; i < 27; i++) {
                    //Get opening brack
                    String bracket = sc.next();
                    assert(bracket.equals("{"));
                    for (int j = 0; j < 27; j++) {
                        P[i][j] = sc.nextDouble();
                    }
                    //Get closing bracket
                    bracket = sc.next();
                    assert(bracket.equals("}"));
                }
        } catch(Exception e) {
            e.printStackTrace();
        }

        return P;
    }

    public static void main(String[] args) {
        double[][] P = GetMatrix();
        for (int i = 0; i<100; ++i) { // generate 100 words
                GenerateWord(P);
        }
    }
}
```