Carnegie Mellon University
Department of Computer Science
15-826 Multimedia Databases and Data Mining
C. Faloutsos, Fall 2019

Homework 2 - Solutions

Due: hard copy, in class, at **1:30pm, on Wed 09/25/2019**
Due: tarball, on Canvas, at **1:30pm, on Wed 09/25/2019**

VERY IMPORTANT:

- For each question, we expect *both* a **hard copy**, and a **tar file** with your code - see details next, on how to package your code.
- Deposit **hard copy** of your answers, in class.
  1. **Separate** your answers, on different page(s) for each question
  2. **Type** the full info on **each** page: your **name**, **Andrew ID**, **course#**, **Homework#**, **Question#** on each of the pages.

Reminders:

- *Plagiarism*: Homework is to be completed *individually*.
- *Typeset* your answers. Illegible handwriting may get zero points.
- *Late homeworks*: please email it
  - to all TAs
  - with the subject line exactly `15-826 Homework Submission (HW 2)`
  - and the count of slip-days you are using.

For your information:

- Graded out of **100** points; **2** questions total
- Rough time estimate: *10-20 hours (≈ 5-10 hours per question)*

Revision : 2019/10/02 01:50

Question	Points	Score
KD-Trees	60	
Z-ordering	40	
Total:	100	

Code packaging instructions:
Submit your code to canvas, in a single `tar` file, called ***andrewId***`-hw2.tar.gz` (where *andrewId* is your andrew id.) For your convenience, we provide a *tar-file package*, at `https://www.cs.cmu.edu/~christos/courses/826.F19/HOMEWORKS/HW2/hw2.tar.gz`. We will refer to it as the *tar-file package* from now on. It has 2 directories `./Q1, ./Q2`, including the k-d-tree and Z-ordering source code, and place-holder code.

- `tar xvf hw2.tar.gz`; `cd Q1; make` # *to work on kdtrees*
- Replace the placeholder code with your solutions, `tar` everything into ***andrewId***`-hw2.tar.gz` and submit to canvas. We expect to do `tar xvfz; make` and see your answers.

Hints:
We strongly recommend that you explore the `makefile`s we have created, for your convenience. For example, from the top directory:

- `make hw2` # *will run the code for all the questions*
- `make package` # *will create the tar file, for submission*
- `make spotless` # *will clean up all the derived files (*.o, etc)*

Make sure that you **exclude** redundant/derived files, in your tar file. Also, it is *your* responsibility to make sure that all necessary files are included in your tarball.

Thus, before submitting your file, do `tar xvfz; make` to make sure it works correctly.

Question 1: KD-Trees ..... [60 points]

On separate page, with '[course-id] [hw#] [question#] [andrew-id] [your-name]'

Problem Description: Consider the k-d-tree package written in C in the directory `./Q1` of the given *tar-file package*. Some functions, such as nn query, count and range query, have already been implemented. You may explore them by using the command lines (`./main`).

- Your task is to add a new function called *minvalue*, and indicated by `m`. It should take as input the dimension (0, 1, ...) and return the minimum value along that dimension.

For example, in a 2-dimenstional tree with the following three points

- 0.3, 0.7
- 0.9, 0.2
- 1.5, -0.1

the minimum value along dimension 0 is: 0.3; and along dimension 1, it is: -0.1.

Input Format: For your convenience, we have already implemented the loading of input data in `main.c`. However, you should still check for input errors (eg., negative dimension-index).

```
$ ./main -d 2
num. dimensions = 2
 i   for insertion
 n   for nn search
 r   for range search
 c   for count
 m   for minimum value (to be implemented)
 p   to print the tree
 x   to exit
 h   to print this help message
kdtree> m
Find min value along dimension: 0
result: N/A (to be implemented)
```

In the example above, the user asks for the minimum value (`m`), on the 0-th dimension, on an empty, 2-dimensional k-dtree.

(a) **[35 points]** Modify the k-d-tree code to support the *minvalue* queries. The output format is as the example above: a single line with the string "result:", the minimum value along that dimension, and a new-line at the end, i.e. `"result:%lf\n"`. Remember to remove all other debugging messages (if any), before you submit the code.

IMPORTANT: Test your code, for corner cases (empty tree, illegal query input, etc), and of course, on the provided datasets (`test[123].txt`). We will also test your code against other 'secret' data which will disclose after the due date.

Solution: Please see `main.c`, `kdtree.h`, and `kdtree.c` for modified codes.

Grading info: -6 for every wrong output on hidden data

(b) **[25 points]** A hard copy of the output of your code, on the three included input scripts (`test1.txt`, `test2.txt`, and `test3.txt`; they are in the `./Q1` directory). Ignore irrelevant lines and keep only the result of minvalue queries, to save paper (eg., `grep result`)

Solution: `test1.txt`: 0.000517, `test2.txt`: 0.000168, `test3.txt`: -0.001131, `test4.txt`: 0.000135, `test5.txt`: -0.001678, `test6.txt`: 1.000000.

Grading info: -4 for every wrong output

What to turn in:

- **Code:** Submit your code to canvas, in the `./Q1` directory of your `tar.gz` file.
- **Answers:** Submit hard copy for
  1. your code (only relevant parts),
  2. and the output of your code on three input files.

Question 2: Z-ordering ..... [40 points]

On separate page, with '[course-id] [hw#] [question#] [andrew-id] [your-name]'

Problem Description: The provided *tar-file package* contains a incorrect implementation of the Z-ordering.

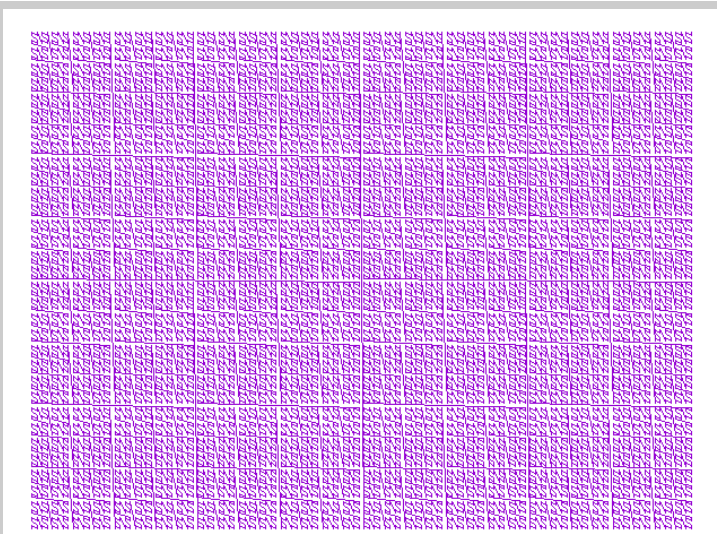
(a) **[25 points]** Fix the bug(s) in the provided code for Z-ordering in `zorder.c`. (We injected one or more bugs, on purpose). The function `zorder()` is supposed to return the Z-order value for the given point. You may use the inverse version of z-order, `izorder()` function, for reference.

Solution:

```
mask = 1 << j;
// Check whether the value in the position is 1
if (coor[i] & mask)
    // Do bit shuffling
    value |= 1 << ((j + 1) * dim - i - 1);
```

Grading info: -3 for unnecessary changes

(b) **[15 points]** Use `zplot.c` to plot a 2-d Z-curve of 7-order ($128 * 128$ grid); The output should be produced in `zcurve.png`. We provide some template code, the `makefile`, and some helper functions. We recommend `gnuplot` for plotting.



Solution:

Grading info: -1 for x and y interchanged

What to turn in:

- **Code:** Submit your code to canvas, in the `./Q2` directory of your `tar.gz` file. Please change only the necessary files.
- **Answers:** Hard copy of
  1. your code in `zorder.c`,
  2. your code in `zdist.c`,
  3. your plot for (b)