Relational Databases and Data Analysis

- As usual, use `zipme.py` to create the archive to upload in ILIAS.

- Assignment 9 will be discussed on December 19. The exercise group for Assignment 10 will take place on January 9. There are no other exercise groups in between.

Exercise 1   *SQL Index*   (1 + 2 + 1 + 2 Points)

Tux the penguin has lost its presents and Christmas hat in an SQL database. You can help Tux retrieve those items by creating an SQL index. A PostgreSQL server must be available.

(a) To return the presents to Tux, create an index in `exercise_1_a.py` to accelerate the following query, which selects pixel colors (red, green, blue) within a certain range and returns their colors and coordinates in the image.

```
SELECT r, g, b, x, y FROM pixel WHERE
    %s <= r AND r <= %s AND
    %s <= g AND g <= %s AND
    %s <= b AND b <= %s
```

(b) To return Tux's hat, consider the following query, which selects all pixels in a ring with inner radius r_0 and outer radius r_1 centered at $(174, 50)$, i.e. all pixels with a distance of at least r_0 and no more than r_1 to the point $(174, 50)$. In `exercise_1_b.py`, write a query and SQL statements such that the query is much faster, but still returns the same pixels.

```
SELECT r, g, b, x, y FROM pixel WHERE
(x - 174)^2 + (y - 50)^2 BETWEEN %s^2 and %s^2
-- Comment: The '%s' correspond to r0   and r1
```

(c) Consider the following query:

```sql
SELECT z FROM mytable WHERE x = 0 AND y = 0
```

Create data (x, y, z) such that the query is slow with an index on x

```sql
CREATE INDEX x_index ON mytable (x)
```

and fast with an index on both x and y.

```sql
CREATE INDEX x_y_index ON mytable (x, y)
```

(d) After inserting your data from the previous exercise into `mytable(x, y, z)`, for example by running `text_exercise_1_c.py`, execute the query

```sql
EXPLAIN ANALYZE SELECT z FROM mytable WHERE x = 0 AND y = 0;
```

for each of the following three cases and paste the result in `exercise_1_d.txt`:

- No index.
- Index on x (You need to create an index for this).
- Index on x and y (You need to create an index for this and drop the index on x).

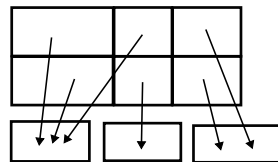Make sure that all three results are different. If they are not, try different data.

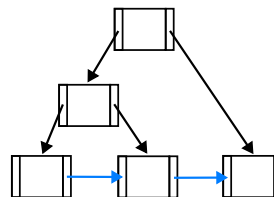**Exercise 2**   *Data Structures*   (4 Points)

(a) Which kind of trees and other data structures from the lecture, **if** any, can be seen here? For each figure, explain by which visual feature you can tell. For figures which could represent multiple different data structures, it is sufficient to choose only one of them.
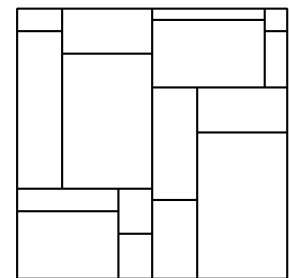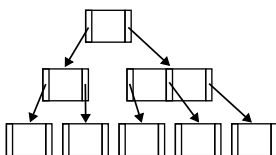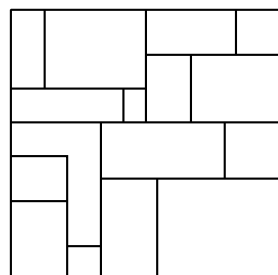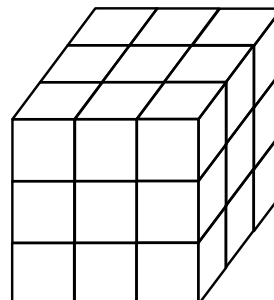

(a)   (b)   (c)   (d)

(e)   (f)   (g)   (h)