TECHNOLOGY AND ALGORITHMS: A SOLUTION TO BEE´S EXTINCTION

Isabella Arango Restrepo
Juan David Rengifo Castro
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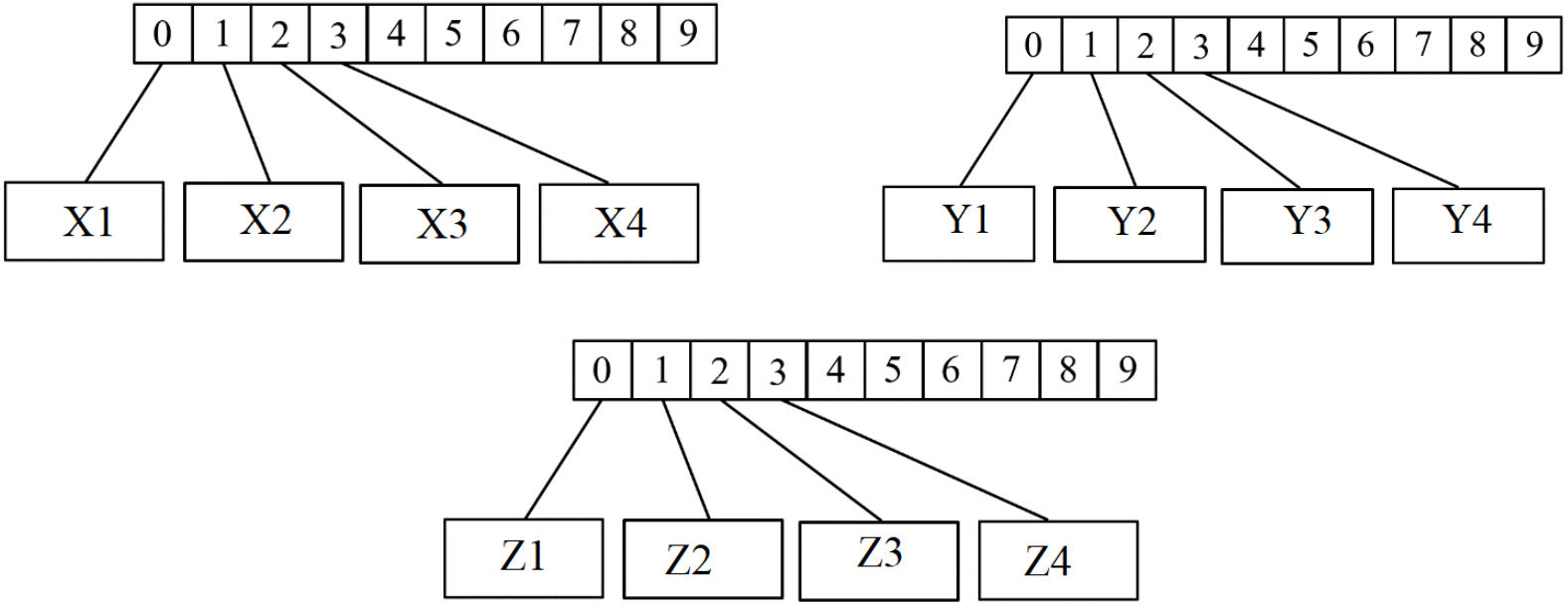
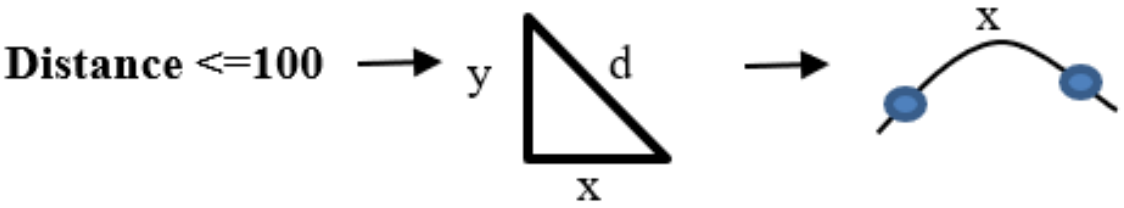
First Data Structure Designed



Graphic 1: ArrayList of bee´s coordinates. A coordinate is double number that represent the latitude, longitude or height.

Data Structure Operations



Graphic 2: Close bees operation with array lists. It compare two coordinates and verify if the distance between them is less than 100m.

Method	Complexity
CloseBees	O(n^2)

Table 1: Complexity of the operations of ArrayLists.

Design Criteria of the Data Structure

- To solve the problem it was necessary to test it with groups of data of different sizes, that is to say that this was not a constant factor.
- The data structure used should be one to which you could add many data and obtain each of its specifications (length, latitude, height).
- The add and get operation in an ArrayList have time complexity of O(1), so they were very efficient no matter the size of the data.

Time and Memory Consumption

Operations	10 bees	100 bees	1000 bees	10000bees
closeBees	3.33ms	23.5ms	394.67ms	23073.67ms

Table 2: Execution time for the method closeBees for different data sets.

	10 bees	100 bees	1000 bees	10000 bees
Memory used	2MB	3MB	4MB	7MB

Table 3: Memory used by different data sets.

Implementation

```
Bee #: 9756 and bee #: 9825 are at 95.36481225782188m.
Bee #: 9760 and bee #: 9778 are at 9.984817737735854m.
Bee #: 9776 and bee #: 9869 are at 82.95451199572m.
Bee #: 9780 and bee #: 9971 are at 98.03196478000936m.
Bee #: 9783 and bee #: 9938 are at 82.05503729468987m.
Bee #: 9789 and bee #: 9893 are at 97.83764463457703m.
Bee #: 9790 and bee #: 9890 are at 88.9715001086929m.
Bee #: 9794 and bee #: 9862 are at 97.65983312687356m.
Bee #: 9796 and bee #: 9808 are at 31.145866102527247m.
Bee #: 9796 and bee #: 9913 are at 97.39101155051945m.
Bee #: 9808 and bee #: 9913 are at 67.54633597178817m.
Bee #: 9814 and bee #: 9826 are at 88.14724400730923m.
Bee #: 9815 and bee #: 9843 are at 56.47192610243705m.
Bee #: 9821 and bee #: 9884 are at 47.089576835808195m.
Bee #: 9828 and bee #: 9977 are at 91.89673160472923m.
Bee #: 9833 and bee #: 9873 are at 99.87646649811163m.
Bee #: 9839 and bee #: 9990 are at 51.941878654384006m.
Bee #: 9842 and bee #: 9933 are at 85.2757801650051m.
Bee #: 9842 and bee #: 9940 are at 33.42387965690543m.
Bee #: 9843 and bee #: 9891 are at 92.3996039545545m.
Bee #: 9844 and bee #: 9944 are at 97.28517296973513m.
Bee #: 9867 and bee #: 9931 are at 93.19547494277548m.
Bee #: 9900 and bee #: 9982 are at 83.70826833887558m.
Bee #: 9901 and bee #: 9953 are at 84.85695457531075m.
Bee #: 9933 and bee #: 9940 are at 96.91435219019583m.
Bee #: 9977 and bee #: 9982 are at 70.55791587971176m.

Memoria máxima: 247MB
Memoria total: 15MB
Memoria libre: 10MB
Memoria usada: 5MB
El tiempo de ejecución es: 20527
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Project.main({ });
Bee #: 3 and bee #: 9 are at 72.97838065101487m.
Bee #: 6 and bee #: 8 are at 73.17524589460847m.

Memoria máxima: 247MB
Memoria total: 15MB
Memoria libre: 9MB
Memoria usada: 6MB
El tiempo de ejecución es: 2
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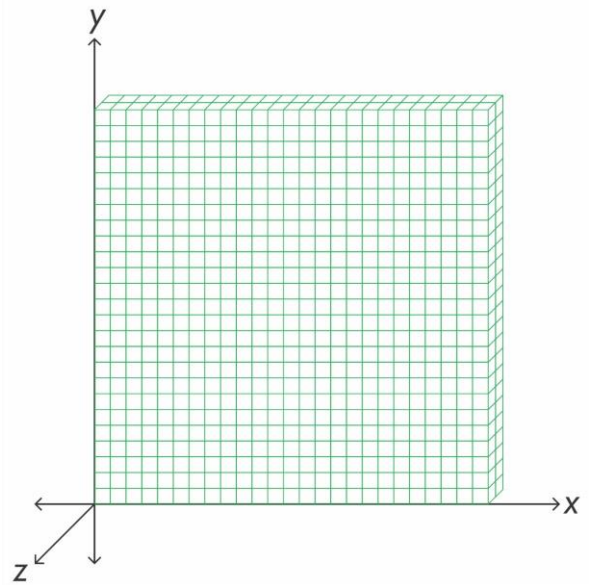
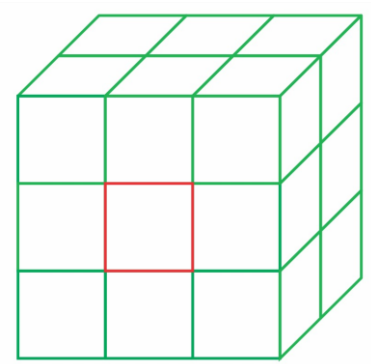
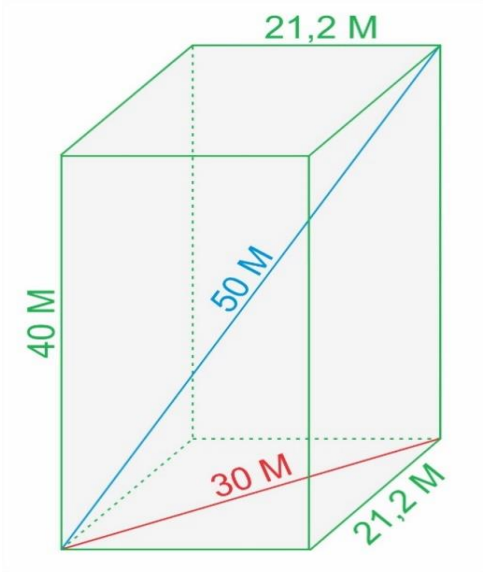
Graphic 3: Bees that have a distance of less than 100m between them.

Second Data Structure Designed

Graphic 4: Map of Bello with its maximum and minimum coordinates

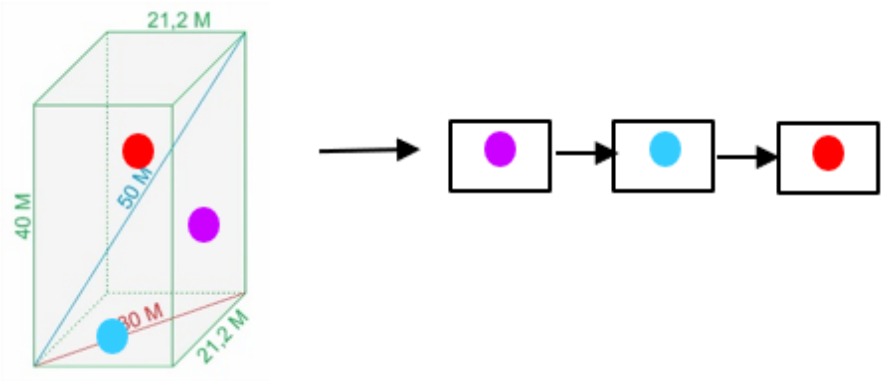






Graphic 5: Representation of the map divided by parallelepipeds of respective measures.

Hash Table Operation



Graphic 6: Addition of bees that are in the same parallelepiped to a LinkedList.

Design Criteria of the Data Structure

- To reduce the time complexity of the first algorithm it was needed to choose another data structure that works well with larger data samples.
- Any operation of the data structure (Hash Table) can be done in constant time, which allows having an efficient algorithm.
- To continue with such low complexity, it was necessary to choose a good data structure to organize the elements in the same parallelepiped, taking into account that the number is not constant.

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