Octrees
Color Quantization

Advanced Data Structures and Algorithms 22/23
M.EIC FEUP

André Pereira
201905650

Beatriz Aguiar
201906230

João Marinho
201905952

Outline

Octrees Overview

Potential Problems

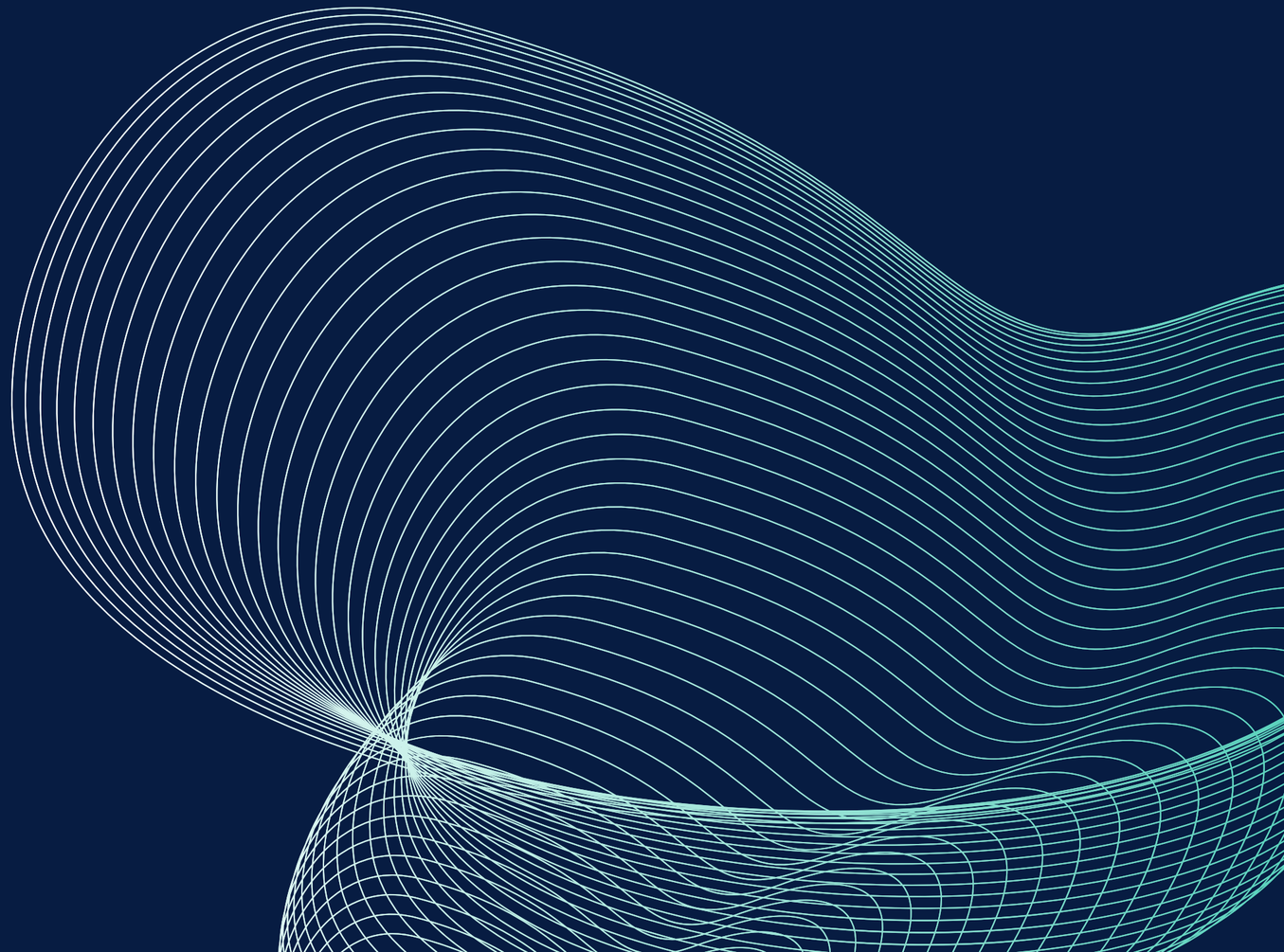
- Collision Detection
- Color Quantization

Real World Application

Solution

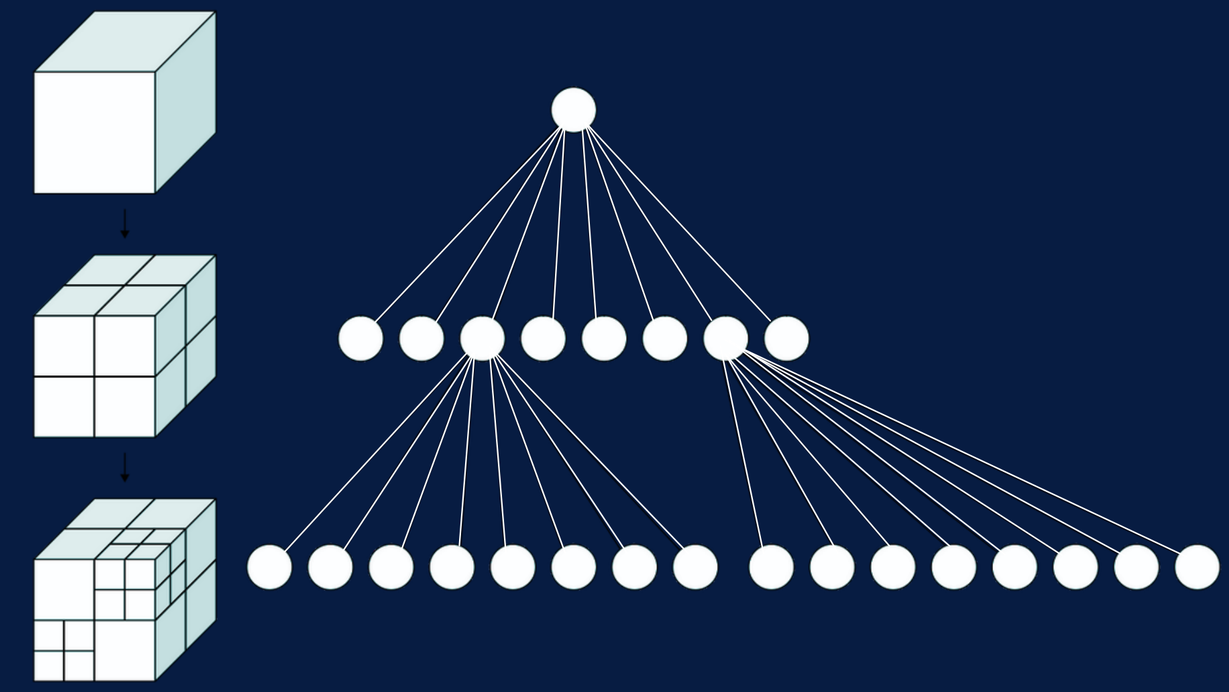
Assessment

Summary



Octrees Overview

Main Operations	Temporal Complexity
• Insertion	O(log n)
• Find	O(log n)
• Query	O(log n) to O(n)



Octrees allow for **efficient storage** and **retrieval of information** about objects within a 3D space.

Potential Problems

Collision Detection

Detecting whether two or more objects in 3D space have collided with each other.

Usage: video games and physics simulations.

Color Quantization

Reduce the number of colors in images without losing quality or information.

Usage: image and video compression.

Nearest Neighbor Search

Find the point or set of points closest to a given point.

Usage: data mining and computer graphics.

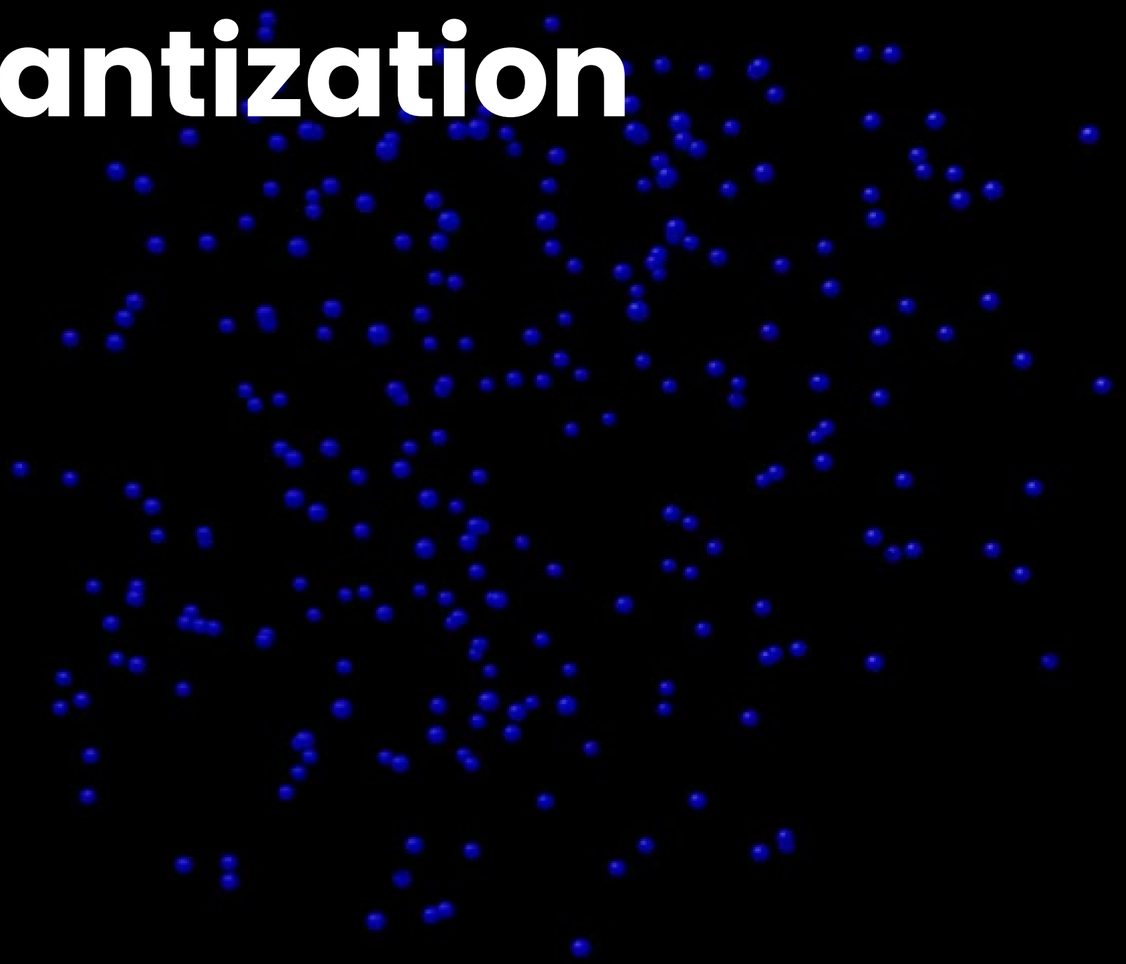
Collision Detection

Collision Detection

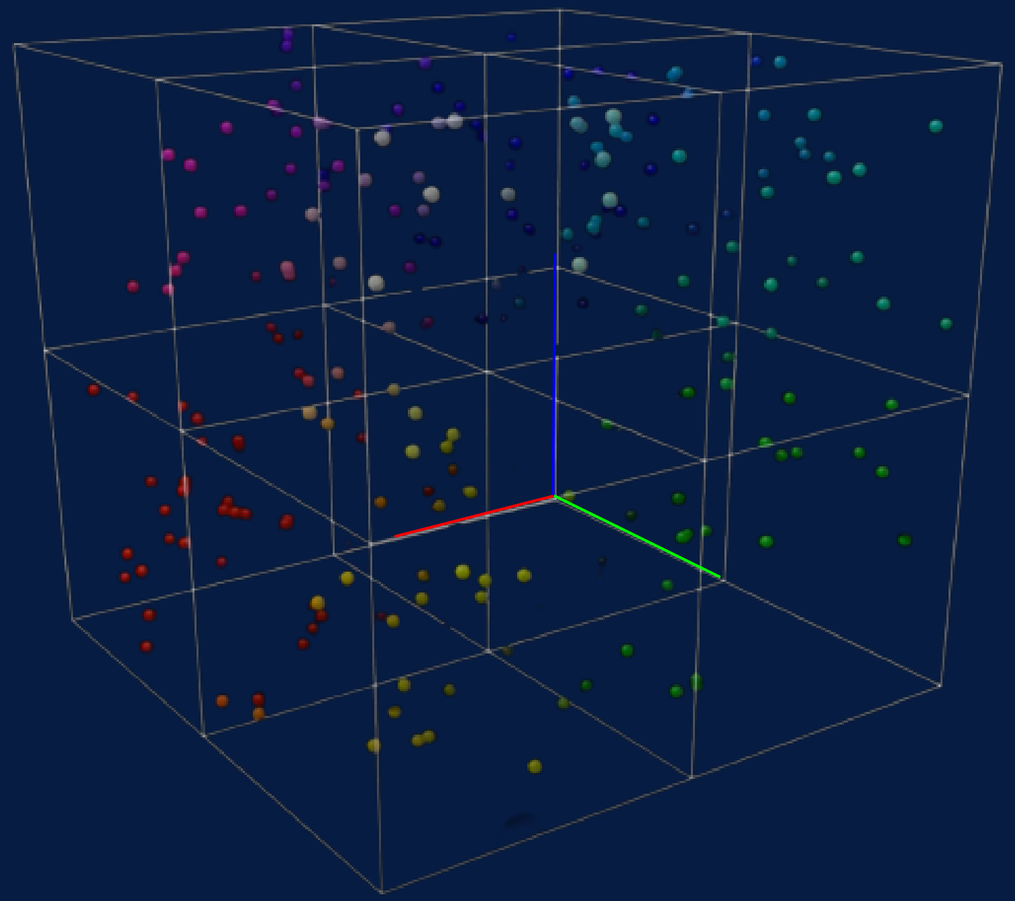
Algorithm 1: `collisionRecurse(node1, node2)`

```
1  begin
2      if node1.isLeaf() and node2.isLeaf() then
3          if overlap(node1.bv, node2.bv) then
4              narrow-phase collision between the octree box in
               node1 and the object in node2
5          return collision status
6      if node2.isLeaf() or (node1.hasChildren() and
       node1.bv > node2.bv) then
7          for i = 1 to 8 do
8              if node1.child(i).occupancy_prob() >
               threshold then
9                  collisionRecurse(node1.child(i),
                   node2)
10     else
11         collisionRecurse(node1, node2.leftChild())
12         collisionRecurse(node1, node2.rightChild())
```

Color Quantization



Color Quantization



Color Quantization

Color quantization for automated fruit quality evaluation

Problem Background

The strong correlation between maturity level and color allows experienced sorters to determine maturity levels by visually examining the color of the fruit

Problem Background

The strong correlation between maturity level and color allows experienced sorters to determine maturity levels by visually examining the color of the fruit

Challenges

- Separate dates in 3 different maturity levels - red, orange & yellow
- Address the detection of surface defects

Problem Background

The strong correlation between maturity level and color allows experienced sorters to determine maturity levels by visually examining the color of the fruit

Challenges

- Separate dates in 3 different maturity levels - red, orange & yellow
- Address the detection of surface defects

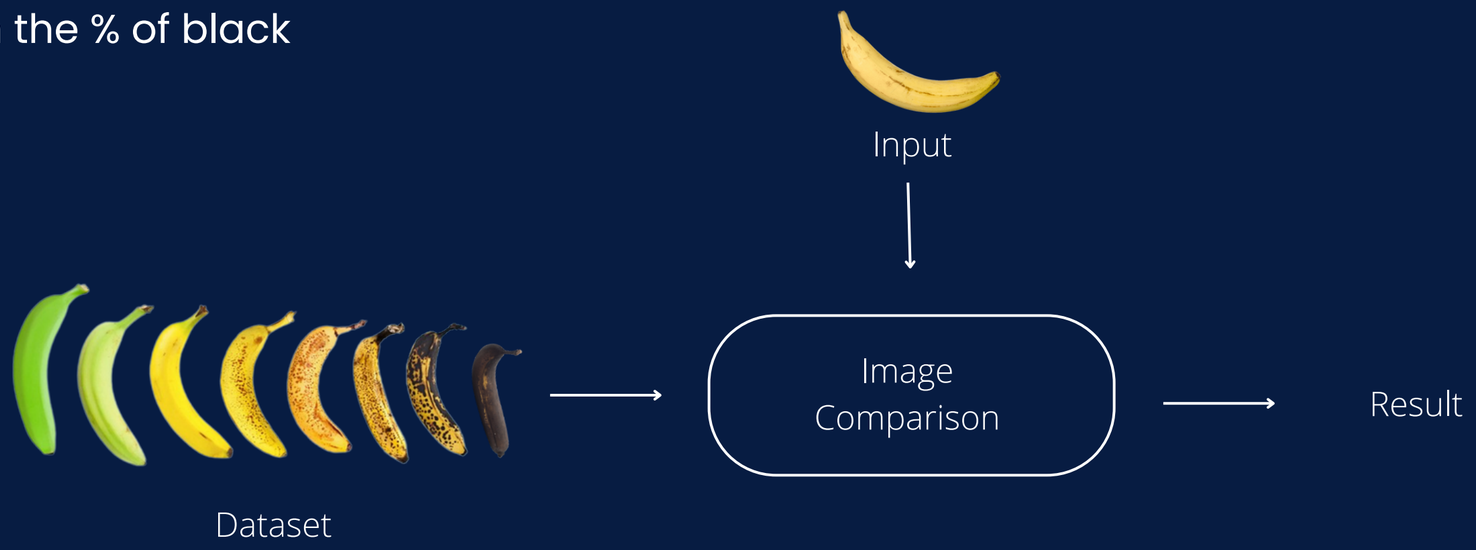
Implementation

$$\text{Color Index} = c_1 RGB + c_2 R^2 + c_3 G^2 + c_4 B^2 + c_5 RG + c_6 RB + c_7 GB + c_8 R + c_9 G + c_{10} B + c_{11}$$

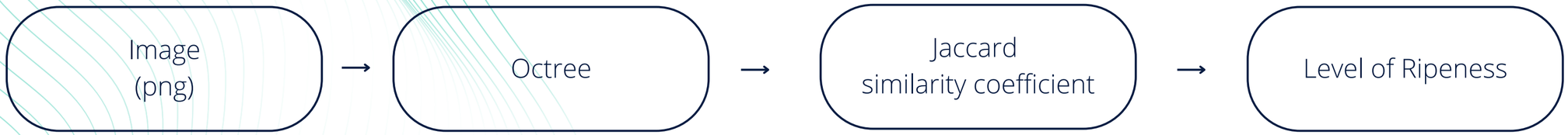
Problem Description

The challenge of the proposed evaluation algorithm is to separate bananas into three different maturity levels - **green, yellow, black**

- Fruit in the first category can be packed immediately for sale
- Fruit in the second category must be further classified based on the shade of orange, as darker yellow colours are more mature.
- Fruit in the third category must also undergo further classification based on the % of black



Solution



MVP
functionalities

- Image conversion into Octree
  - Insertion
- Comparison algorithm
  - Jaccard similarity coefficient

$$J(A, B) = \frac{|A \cap B|}{|A \cup B|}$$

Dataset

Self created dataset

Follow the ripeness evolution of 3 store-bought bananas and photograph them daily for 2 weeks

+

Labeled dataset

Gather internet labeled example images

Tests

→ Green ✓

→ Yellow ✓

→ Green ✗

→ Black ✓

Testing dataset: 300 images

Results

Effective if accuracy > 80% •

time < 60s •

Summary

Octree

Octrees are a type of spatial data structure that partitions the 3D space into smaller and smaller cubes (8 cubes at time), allowing for efficient storage and retrieval of information about objects within that space.

Color quantization

A process that reduces the number of colors in images without losing quality and important global information.

Image conversion

Images are converted into octrees.

Each leaf node corresponds to a color and is represented in a 3D RGB world.

Fruit quality evaluation

The product will evaluate the level of ripeness of a banana image, given as input.

The image will be compared with a dataset of labeled bananas using the Jaccard coefficient algorithm.

Questions?

References

D. J. Lee, Y. Chang, J. K. Archibald and C. G. Greco, "Color quantization and image analysis for automated fruit quality evaluation," 2008 IEEE International Conference on Automation Science and Engineering, Arlington, VA, USA, 2008, pp. 194-199, doi: 10.1109/COASE.2008.4626418.

Jaccard index. (2023, March 12). In Wikipedia. https://en.wikipedia.org/wiki/Jaccard_index