Algorithms Experiment 2

IMPLEMENTATION OF
POLYGON TRIANGULATION &
EXPLORING DATABASES

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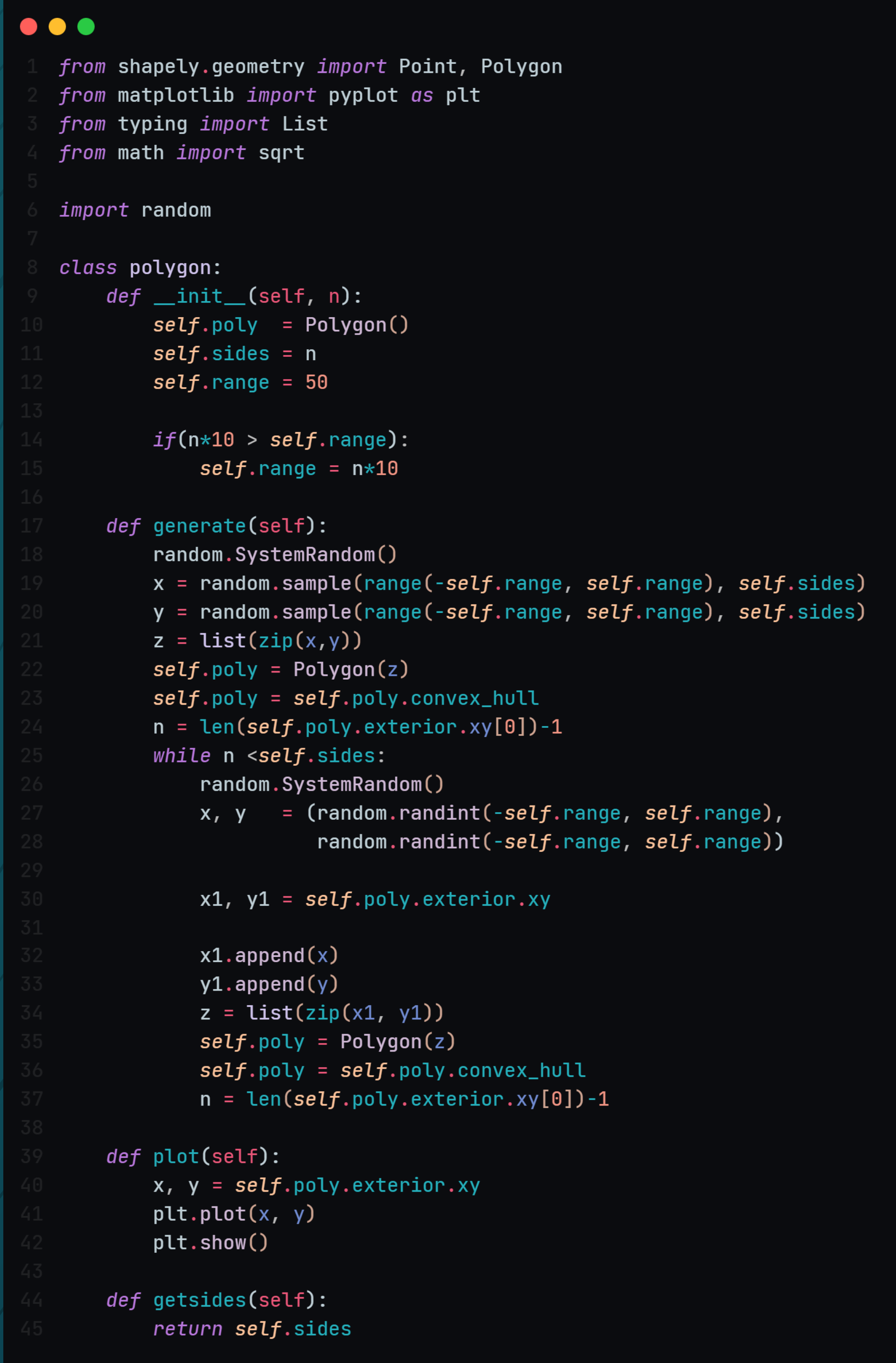
1

POLYGON TRIANGULATION

Implementing the Polygon Triangulation Problem using different approaches of algorithmic programming

<CLASS DESIGN FOR POLYGONS>

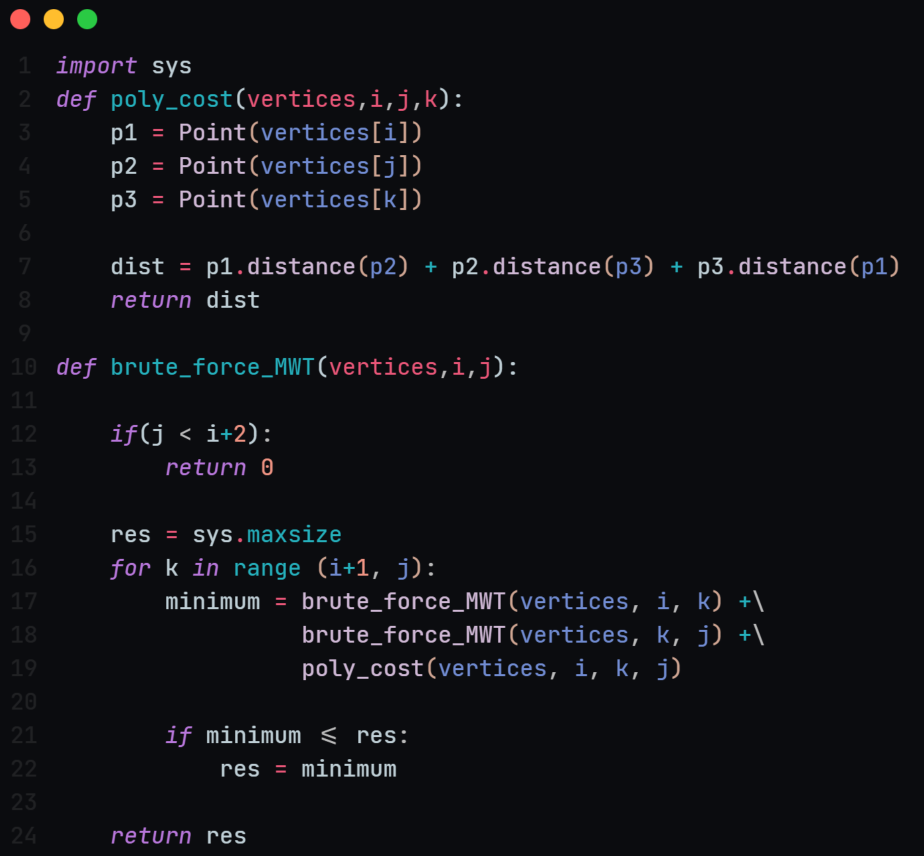
- `__init__`: Constructor for the class polygon
- `generate`: generates the random vertices for the polygon
- `plot`   : plots the data in matplotlib
- `getsides`: returns the no. of sides in the generated convex polygon



```python
from shapely.geometry import Point, Polygon
from matplotlib import pyplot as plt
from typing import List
from math import sqrt

import random

class polygon:
    def __init__(self, n):
        self.poly  = Polygon()
        self.sides = n
        self.range = 50

        if(n*10 > self.range):
            self.range = n*10

    def generate(self):
        random.SystemRandom()
        x = random.sample(range(-self.range, self.range), self.sides)
        y = random.sample(range(-self.range, self.range), self.sides)
        z = list(zip(x,y))
        self.poly = Polygon(z)
        self.poly = self.poly.convex_hull
        n = len(self.poly.exterior.xy[0])-1
        while n <self.sides:
            random.SystemRandom()
            x, y   = (random.randint(-self.range, self.range),
                          random.randint(-self.range, self.range))

            x1, y1 = self.poly.exterior.xy

            x1.append(x)
            y1.append(y)
            z = list(zip(x1, y1))
            self.poly = Polygon(z)
            self.poly = self.poly.convex_hull
            n = len(self.poly.exterior.xy[0])-1

    def plot(self):
        x, y = self.poly.exterior.xy
        plt.plot(x, y)
        plt.show()

    def getsides(self):
        return self.sides
```

<BRUTE FORCE APPROACH>

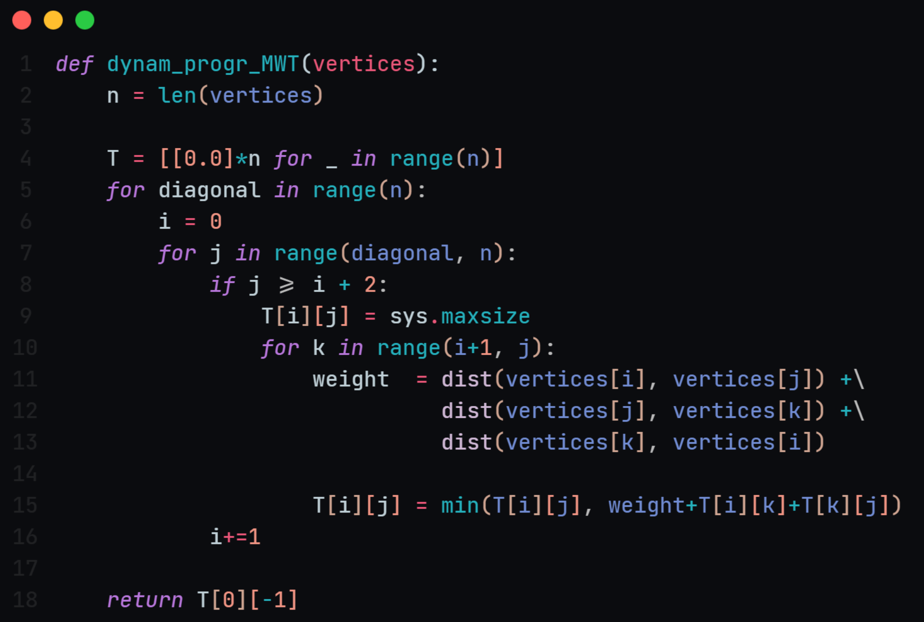
- poly_cost : calculate the cost (perimeter) for triangulation
- brute_force_MWT: uses the brute-force approach to calculate the minimum cost of triangulation for the given polygon.



```python
import sys
def poly_cost(vertices,i,j,k):
    p1 = Point(vertices[i])
    p2 = Point(vertices[j])
    p3 = Point(vertices[k])

    dist = p1.distance(p2) + p2.distance(p3) + p3.distance(p1)
    return dist

def brute_force_MWT(vertices,i,j):

    if(j < i+2):
        return 0

    res = sys.maxsize
    for k in range (i+1, j):
        minimum = brute_force_MWT(vertices, i, k) +\
                  brute_force_MWT(vertices, k, j) +\
                  poly_cost(vertices, i, k, j)

        if minimum ≤ res:
            res = minimum

    return res
```

<DYNAMIC PROGRAMMING APPROACH>

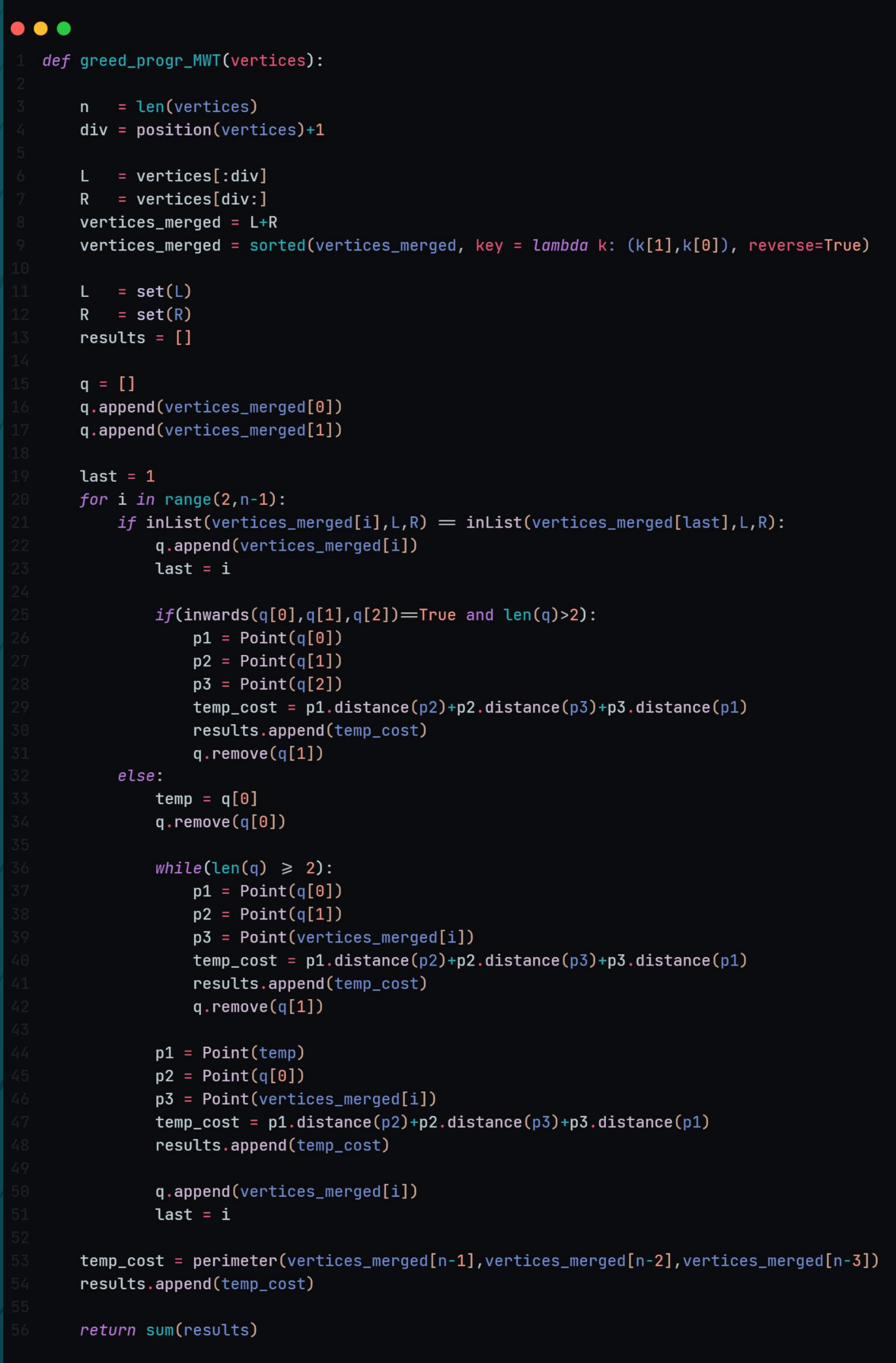
- dynam_progr_MWT: uses the dynamic programming approach to find the minimum cost of triangulation for the given polygon.



```python
def dynam_progr_MWT(vertices):
    n = len(vertices)

    T = [[0.0]*n for _ in range(n)]
    for diagonal in range(n):
        i = 0
        for j in range(diagonal, n):
            if j >= i + 2:
                T[i][j] = sys.maxsize
                for k in range(i+1, j):
                    weight  = dist(vertices[i], vertices[j]) +\
                              dist(vertices[j], vertices[k]) +\
                              dist(vertices[k], vertices[i])

                    T[i][j] = min(T[i][j], weight+T[i][k]+T[k][j])
            i+=1

    return T[0][-1]
```

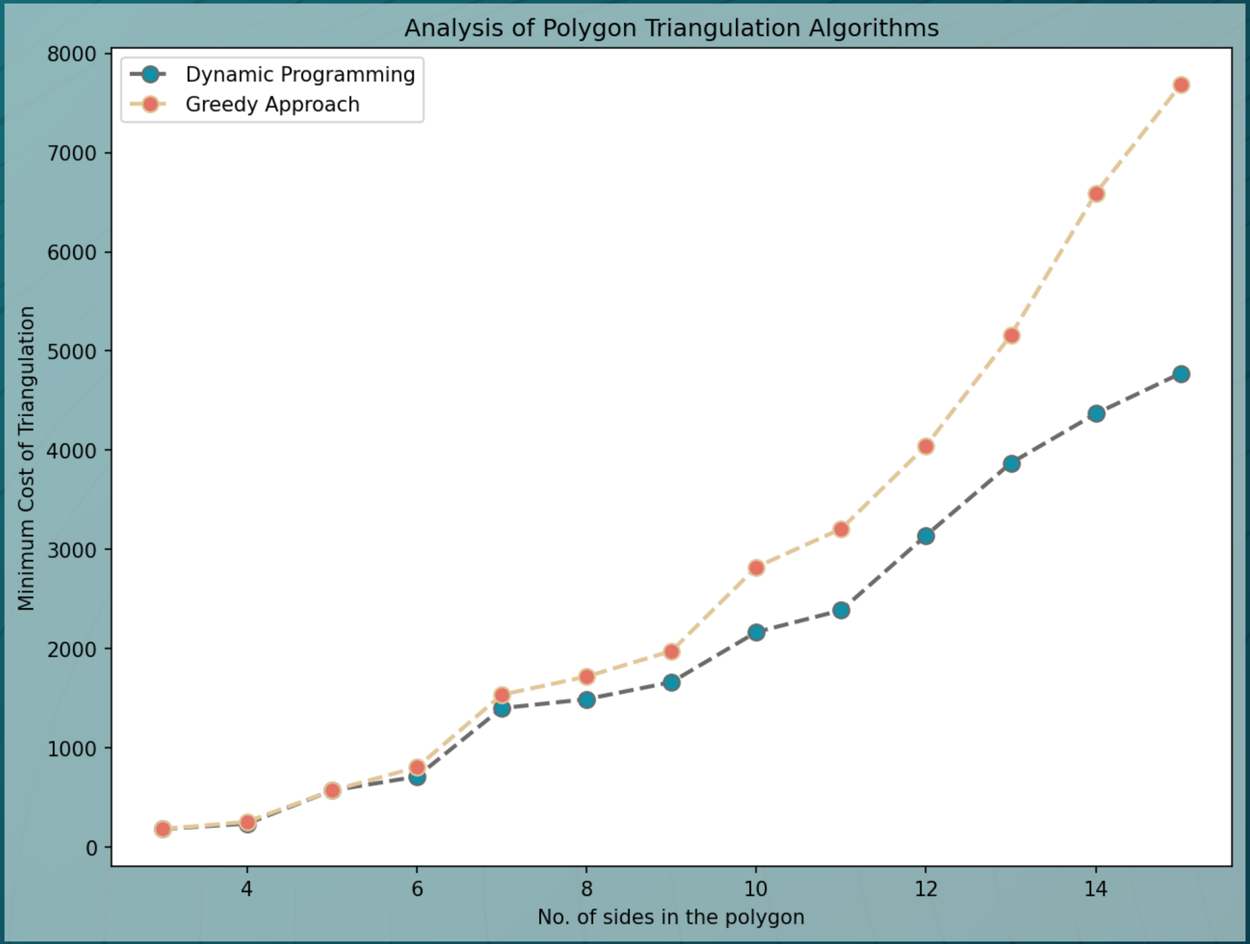
<GREEDY PROGRAMMING APPROACH>

- greed_progr_MWT: uses the greedy programming to quickly triangulate a polygon. Later on we will check whether whether the triangulation is actually the minimum triangulation.



```python
def greed_progr_MWT(vertices):

    n   = len(vertices)
    div = position(vertices)+1

    L   = vertices[:div]
    R   = vertices[div:]
    vertices_merged = L+R
    vertices_merged = sorted(vertices_merged, key = lambda k: (k[1],k[0]), reverse=True)

    L   = set(L)
    R   = set(R)
    results = []

    q = []
    q.append(vertices_merged[0])
    q.append(vertices_merged[1])

    last = 1
    for i in range(2,n-1):
        if inList(vertices_merged[i],L,R) == inList(vertices_merged[last],L,R):
            q.append(vertices_merged[i])
            last = i

            if(inwards(q[0],q[1],q[2])==True and len(q)>2):
                p1 = Point(q[0])
                p2 = Point(q[1])
                p3 = Point(q[2])
                temp_cost = p1.distance(p2)+p2.distance(p3)+p3.distance(p1)
                results.append(temp_cost)
                q.remove(q[1])
        else:
            temp = q[0]
            q.remove(q[0])

            while(len(q) >= 2):
                p1 = Point(q[0])
                p2 = Point(q[1])
                p3 = Point(vertices_merged[i])
                temp_cost = p1.distance(p2)+p2.distance(p3)+p3.distance(p1)
                results.append(temp_cost)
                q.remove(q[1])

            p1 = Point(temp)
            p2 = Point(q[0])
            p3 = Point(vertices_merged[i])
            temp_cost = p1.distance(p2)+p2.distance(p3)+p3.distance(p1)
            results.append(temp_cost)

            q.append(vertices_merged[i])
            last = i

    temp_cost = perimeter(vertices_merged[n-1],vertices_merged[n-2],vertices_merged[n-3])
    results.append(temp_cost)

    return sum(results)
```

Sample Plots



ANALYSIS

- The dynamic programming approach takes O(n3) while the implementations of Seidel’s Algorithm in the Greedy Approach takes the complexity of O(n*logn) which in this case was $O(n^2 logn)$.
- However it is noticeable that the Greedy approach does not always give the minimum triangulation of the polygon, especially in those with larger number of sides. But it is considerably faster so it can be used as an alternative for the dynamic programming approach if accuracy is not a very important factor.

2

EXPLORING DATABASES

Exploring the SNAP and KONECT databases and try running different algorithms like MST, Disjoint Sets etc.

<STANFORD NETWORK ANALYSIS PROJECT>

- Stanford Network Analysis Platform (SNAP) is a general purpose network analysis and graph mining library. It is written in C++ and easily scales to massive networks with hundreds of millions of nodes, and billions of edges. It efficiently manipulates large graphs, calculates structural properties, generates regular and random graphs, and supports attributes on nodes and edges.
- It is also supported on Python under Snap.py