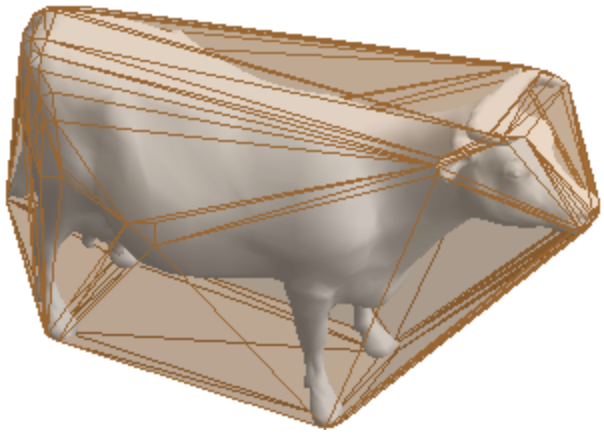
LAPORAN TUGAS KECIL II

IMPLEMENTASI CONVEX HULL UNTUK VISUALISASI TES LINEAR SEPARABILITY DATASET DENGAN ALGORITMA DIVIDE AND CONQUER

Laporan dibuat untuk memenuhi salah satu tugas mata kuliah

IF2211 Strategi Algoritma



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PROGRAM STUDI TEKNIK INFORMATIKA

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DAFTAR ISI

Algoritma *Divide and Conquer*

Algoritma *Divide and Conquer* adalah pendekatan yang membagi persoalan menjadi beberapa upa-persoalan yang memiliki kemiripan dengan persoalan semula namun berukuran lebih kecil kemudian masing-masing upa-persoalan diselesaikan dn digabung membentuk solusi persoalan semula. Pada tugas kecil kedua ini, persoalan yang akan diselesaikan adalah pembentukan *convex hull* dari kumpulan data titik pada bidang dua dimensi. Himpunan titik pada bidang planar disebut *convex* jika untuk sembarang dua titik pada bidang tersebut (misal *p* dan *q*), seluruh segmen garis yang berakhir di *p* dan *q* berada pada himpunan tersebut. *Convex hull* dari himpunan titik S adalah himpunan *convex* terkecil yang mengandung S.

Pencarian *convex hull* dilakukan dengan menemukan kumpulan titik 'terluar' yang membentuk *convex hull*. Berikut adalah langkah-langkahnya.

1. Urutkan semua titik pada himpunan titik *S* berdasarkan koordinat x-nya.
2. Ambil titik paling kiri dan paling kanan, misal *p1* dan *pn*.
3. Masukkan garis yang menghubungkan *p1* dan *pn*, *p1pn* dan *pnp1*, ke dalam himpunan solusi. Garis *p1pn* membagi *S* menjadi dua bagian yaitu *S1* (kumpulan titik di sebelah kiri atau atas garis *p1pn*) dan *S2* (kumpulan titik di sebelah kanan atau bawah garis *p1pn* atau bisa juga di sebelah kiri atau atas garis *pnp1*). Untuk memeriksa letak suatu titik apakah ada di sebelah kiri (atau atas) suatu garis yang dibentuk dua titik, digunakan perhitungan determinan.
4. Pada *S1*, cari titik yang paling jauh dari garis *p1pn*, misal *pm*. Hapus garis *p1pn* pada himpunan solusi dan ganti dengan *p1pm* dan *pmpn*. Garis *p1pm* dan *pmpn* membagi *S1* menjadi empat bagian. Kita hanya perlu menghitung bagian sebelah kiri atau atas garisnya saja, misalkan *S11* dan *S12*.
5. Ulangi langkah nomor 4 untuk *S11* dan *S12* sampai tidak ada lagi titik terjauh di sebelah kiri atau atas sebuah garis.
6. Ulangi langkah pada nomor 4 dan 5 untuk *S2*.

Kode Program

Kode program ditulis dalam bahasa Python. Kode ditulis dengan menggunakan python notebook dan terbagi ke dalam beberapa bagian. Bagian pertama yaitu kode untuk mencari *convex hull*, bagian kedua yaitu kode untuk membentuk *data frame*, dan terakhir kode untuk menampilkan visualisasi *convex hull*. Di bawah ketiga bagian ini, terdapat beberapa potongan kode yang sengaja ditulis untuk memperlihatkan bentuk *convex hull* dari beberapa dataset yang disediakan dan juga untuk mempermudah penulisan laporan. Potongan kode di bagian akhir tidak ditulis di laporan karena sama persis dengan bagian kedua dan bagian ketiga dan hanya berbeda di data set yang digunakan .

Bagian Pencari Convex Hull

Bagian ini terdiri dari tiga kelas, yaitu kelas Point, kelas Line, dan kelas myConvexHull itu sendiri. Berikut adalah kode program dari bagian ini.

```
class Point:
    """
    This class defines points in two dimensions plus saves an order
    number so that it can be used by matplotlib.

    Attributes and constructor parameters:
        x (float): x-axis coordinate.
        y (float): y-axis coordinate.
        order (int): serial number of a point.
    """
    def __init__(self, x, y, order):
        self.x = float(x)
        self.y = float(y)
        self.order = order

    def __str__(self):
        return "[" + str(self.x) + ", " + str(self.y) +"] " +
str(self.order)

    def getX(self):
        return self.x

    def getY(self):
        return self.y
```

```
    def get_order(self):
        return self.order


class Line:
    """
    This class defines a line between two points.

    Attributes:
        p1 (Point): first point.
        p2 (Point): second point.
        order_pair (array of int): a pair of point serial number.
    """
    def __init__(self, p1, p2):
        """
        The constructor for Line class.

        Paramaters:
            p1 (Point): first point.
            p2 (Point): second point.
        """
        self.p1 = p1
        self.p2 = p2
        self.order_pair = [p1.get_order(), p2.get_order()]

    def get_order_pair(self):
        return self.order_pair

    def __str__(self):
        return "[[" + str(self.p1.getX()) + ", " + str(self.p1.getY())
+"], " + "[" + str(self.p2.getX()) + ", " + str(self.p2.getY()) +"]]"

    def __eq__(self, other):
        return self.p1 == other.p1 and self.p2 == other.p2


class myConvexHull:
    """
    Convex hulls in two dimensions.
```

```
    Attributes:
        points (array of Points): coordinates of points to construct a
convex hull from.
        solution (array of Lines): vertices that form a convex hull.
        simplices (array of int): indices of points forming the simplical
facets of the convex hull.
    """
    def __init__(self, points):
        """
        Constructor of myConvexHull Class.

        Parameters:
            points (array of Points): coordinates of points to construct a
convex hull from.
        """
        self.points = []
        i = 0
        for point in points:
            self.points.append(Point(point[0], point[1], i))
            i += 1
        self.solution = []
        self.solve()
        self.simplices = []
        for line in self.solution:
            self.simplices.append(line.get_order_pair())

    def partition(self, left_index, right_index):
        """
        Function that partitioning an array of Points for quick sort
purpose.

        Parameters:
            left_index (int): start index
            right_index (int): last index
        """
        pivot_index = right_index
        pivot = self.points[pivot_index]
        right_index -= 1
```

```
        while True:
            while self.points[left_index].getX() < pivot.getX():
                left_index += 1

            while self.points[right_index].getX() > pivot.getX():
                right_index -= 1

            if left_index >= right_index:
                break
            else:
                point_temp = self.points[left_index]
                self.points[left_index] = self.points[right_index]
                self.points[right_index] = point_temp

            left_index += 1

        point_temp = self.points[left_index]
        self.points[left_index] = self.points[pivot_index]
        self.points[pivot_index] = point_temp

        return left_index

    def quicksort(self, left_index, right_index):
        """
        Function to perform quick sort on an array of Points.

        Parameters:
            left_index (int): start index
            right_index (int): last index
        """
        if right_index - left_index <= 0:
            return

        pivot_index = self.partition(left_index, right_index)
        self.quicksort(left_index, pivot_index - 1)
        self.quicksort(pivot_index + 1, right_index)

    def determinant(self, p1, p2, p3):
        """
```

```
        Function to calculate determinants to check if point p3 is on the
left (or above)
        or on the right (or below) a line between two points p1 and p2.

        Parameters:
            p1 (Point): first point
            p2 (Point): second point
            p3 (Point): point to check
        """
        # x1*y2 + x3*y1 + x2*y3 - x3*y2 - x2*y1 - x1*y3
        return p1.getX()*p2.getY() + p3.getX()*p1.getY() +
p2.getX()*p3.getY() - p3.getX()*p2.getY() - p2.getX()*p1.getY() -
p1.getX()*p3.getY()

    def distance(self, p1, p2, p3):
        """
        Function to calculate distance between a point p3 and a line
between
        two points p1 and p2.

        Parameters:
            p1 (Point): first point
            p2 (Point): second point
            p3 (Point): point to check
        """
        return abs(((p2.getX()-p1.getX()) * (p1.getY()-p3.getY())) -
((p1.getX()-p3.getX())*(p2.getY()-p1.getY()))) /
(((p2.getX()-p1.getX())**2 + (p2.getY()-p1.getY())**2)**0.5)

    def solve(self):
        """
        Procedure to find the solutions using the divide and conquer
approach
        """
        # Sort the array of points
        self.quicksort(0, len(self.points) - 1)
        N = len(self.points)

        leftmost_p = self.points[0]
        rightmost_p = self.points[N-1]
```

```
        # put the Line between the leftmost point and the rightmost point
        # to the solution set
        self.solution.append(Line(leftmost_p, rightmost_p))
        self.solution.append(Line(rightmost_p, leftmost_p))

        # devide the array of points using the determinant
        s1 = []
        s2 = []
        for i in range(1, N-1):
            if self.determinant(leftmost_p, rightmost_p, self.points[i]) >
0:
                s1.append(self.points[i])
            elif self.determinant(leftmost_p, rightmost_p, self.points[i])
< 0:
                s2.append(self.points[i])

        # process each set using a recursive method
        self.convex_hull_recursive(s1, leftmost_p, rightmost_p)
        self.convex_hull_recursive(s2, rightmost_p, leftmost_p)


    def convex_hull_recursive(self, points, leftmost, rightmost):
        """
        Procedure for conducting further searches for
        solutions using a divide and conquer approach and a recursive
method

        Parameters:
            points (array of Points): coordinates of points to construct a
convex hull from.
            leftmost (Point): the leftmost point.
            rightmost (Point): the rightmost point.
        """
        if len(points) == 0:
            return
        else:
            # Find the point that is the farthest away from the line
between
            # the leftmost and rightmost points
```

```
            farthest_p_dist = -999
            farthest_p = None
            for i in range(len(points)):
                temp = self.distance(leftmost, rightmost, points[i])
                if (temp > farthest_p_dist and temp > 0 and farthest_p !=
leftmost and farthest_p != rightmost):
                    farthest_p_dist = temp
                    farthest_p = points[i]

            if farthest_p:
                # replace the solution set with the new one
                temp = Line(leftmost, rightmost)

self.solution.insert(self.solution.index(temp),Line(leftmost, farthest_p))

self.solution.insert(self.solution.index(temp),Line(farthest_p,
rightmost))
                self.solution.remove(temp)

                # take all the points on the left of the line
                s11 = []
                s12 = []

                for i in range(0, len(points)):
                    if self.determinant(leftmost, farthest_p, points[i]) >
0:
                        s11.append(points[i])
                    if self.determinant(farthest_p, rightmost, points[i])
> 0:
                        s12.append(points[i])

                # process each point set
                self.convex_hull_recursive(s11, leftmost, farthest_p)
                self.convex_hull_recursive(s12, farthest_p, rightmost)
```

Bagian Pembuat *Dataframe*

Pada bagian ini, user dapat memilih satu dari empat data set yang disediakan, yaitu data set Iris, Wine, Digits, dan Breast Cancer. Berikut adalah kode program dari bagian ini.

```
import pandas as pd
import matplotlib.pyplot as plt
from sklearn import datasets

print("1. Iris")
print("2. Wine")
print("3. Digits")
print("4. Breast Cancer")
user_pick = int(input("Pick a dataset (1-4): "))
isValid = True
if user_pick == 1:
    data = datasets.load_iris()
elif user_pick == 2:
    data = datasets.load_wine()
elif user_pick == 3:
    data = datasets.load_digits()
elif user_pick == 4:
    data = datasets.load_breast_cancer()
else:
    print("Unkown input.")
    isValid = False

if isValid:
    # create a DataFrame
    df = pd.DataFrame(data.data, columns=data.feature_names)
    df['Target'] = pd.DataFrame(data.target)
    df
```

Bagian Visualisasi

Berikut adalah kode program dari bagian ini.

```
if isValid:
    # Visualization
    plt.figure(figsize = (10, 6))
    colors = ['b', 'y', 'g', 'r', 'c', 'm', 'k']

    print("Please pick two different features to be compared.")
```

```
    i = 0
    while i < len(data.feature_names):
        print(f"{i+1}. {data.feature_names[i]}")
        i += 1
    feature_pick_1 = int(input(f"First pick(1-{i}): "))
    feature_pick_2 = int(input(f"Second pick(1-{i}): "))

    if feature_pick_1 == feature_pick_2 or feature_pick_1 > i+1 or
feature_pick_1 < 1 or feature_pick_2 > i+1 or feature_pick_2 < 1:
        isValid = False

    if isValid:
        plt.title(f'{data.feature_names[feature_pick_1-1]} vs
{data.feature_names[feature_pick_2-1]}')
        plt.xlabel(data.feature_names[feature_pick_1-1])
        plt.ylabel(data.feature_names[feature_pick_2-1])
        for i in range(len(data.target_names)):
            bucket = df[df['Target'] == i]
            bucket = bucket.iloc[:,[0,1]].values
            hull = myConvexHull(bucket)
            plt.scatter(bucket[:, 0], bucket[:, 1],
label=data.target_names[i])
            for simplex in hull.simplices:
                plt.plot(bucket[simplex, 0], bucket[simplex, 1],
colors[i%7])
        plt.legend()
```

Tangkapan Layar Uji Coba Program

Data Set Iris

```python
import pandas as pd
import matplotlib.pyplot as plt
from sklearn import datasets

iris = datasets.load_iris()
# create a DataFrame
df1 = pd.DataFrame(iris.data, columns=iris.feature_names)
df1['Target'] = pd.DataFrame(iris.target)
df1
```

✓ 0.9s MagicPython

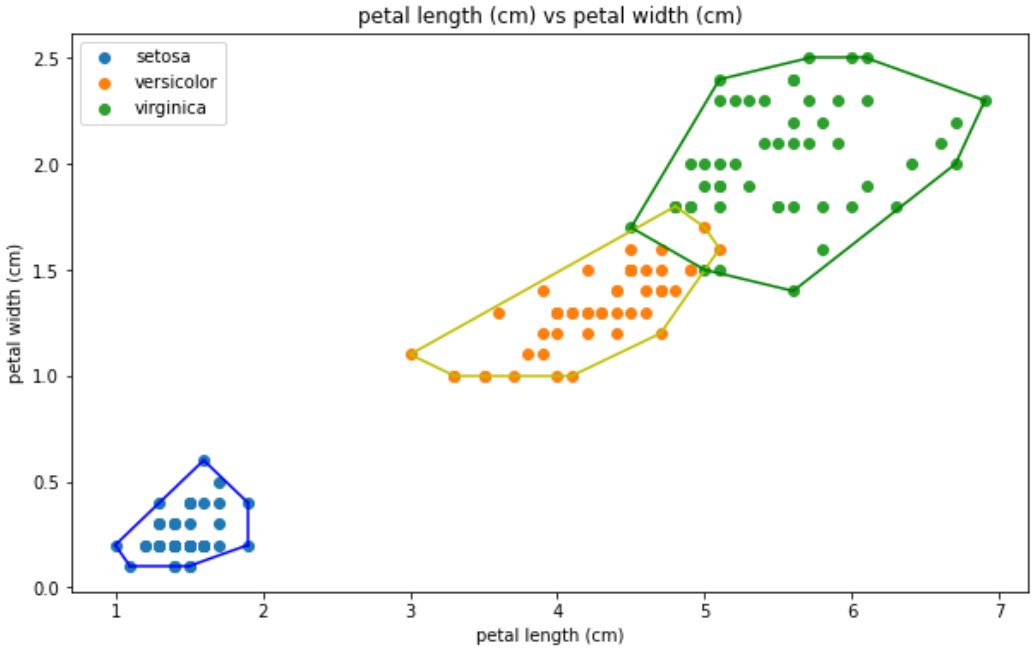
	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	Target
0	5.1	3.5	1.4	0.2	0
1	4.9	3.0	1.4	0.2	0
2	4.7	3.2	1.3	0.2	0
3	4.6	3.1	1.5	0.2	0
4	5.0	3.6	1.4	0.2	0
...	...	...	...	...	...
145	6.7	3.0	5.2	2.3	2
146	6.3	2.5	5.0	1.9	2
147	6.5	3.0	5.2	2.0	2
148	6.2	3.4	5.4	2.3	2
149	5.9	3.0	5.1	1.8	2

150 rows × 5 columns

Petal Length vs Petal Width

```python
# Visualization
plt.figure(figsize = (10, 6))
colors = ['b', 'y', 'g', 'r', 'c', 'm', 'k']
plt.title(f'{iris.feature_names[2]} vs {iris.feature_names[3]}')
plt.xlabel(iris.feature_names[2])
plt.ylabel(iris.feature_names[3])
for i in range(len(iris.target_names)):
    bucket = df1[df1['Target'] == i]
    bucket = bucket.iloc[:,[2,3]].values
    hull = myConvexHull(bucket)
    plt.scatter(bucket[:, 0], bucket[:, 1], label=iris.target_names[i])
    for simplex in hull.simplices:
        plt.plot(bucket[simplex, 0], bucket[simplex, 1], colors[i%7])
plt.legend()
```

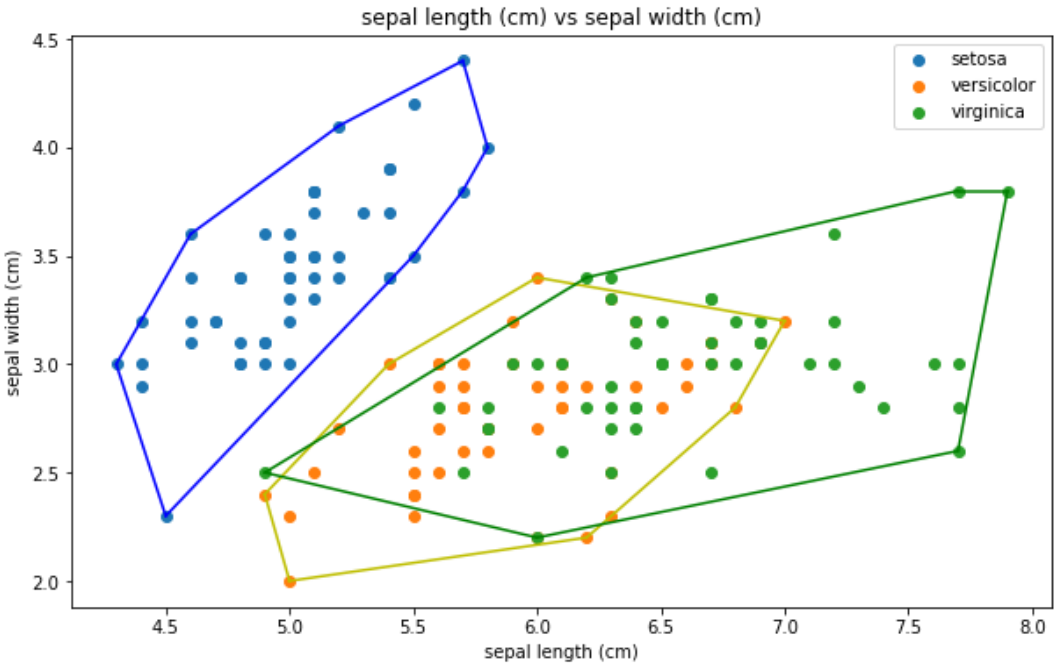
✓ 0.3s MagicPython



Sepal Length vs Sepal Width

```python
# Visualization
plt.figure(figsize = (10, 6))
colors = ['b', 'y', 'g', 'r', 'c', 'm', 'k']
plt.title(f'{iris.feature_names[0]} vs {iris.feature_names[1]}')
plt.xlabel(iris.feature_names[0])
plt.ylabel(iris.feature_names[1])
for i in range(len(iris.target_names)):
    bucket = df1[df1['Target'] == i]
    bucket = bucket.iloc[:,[0,1]].values
    hull = myConvexHull(bucket)
    plt.scatter(bucket[:, 0], bucket[:, 1], label=iris.target_names[i])
    for simplex in hull.simplices:
        plt.plot(bucket[simplex, 0], bucket[simplex, 1], colors[i%7])
plt.legend()
```

✓ 0.3s MagicPython



Data Set Breast Cancer

```
1  breast_cancer = datasets.load_breast_cancer()
2  df2 = pd.DataFrame(breast_cancer.data, columns=breast_cancer.feature_names)
3  df2['Target'] = pd.DataFrame(breast_cancer.target)
4  df2
```

✓ 0.1s MagicPython

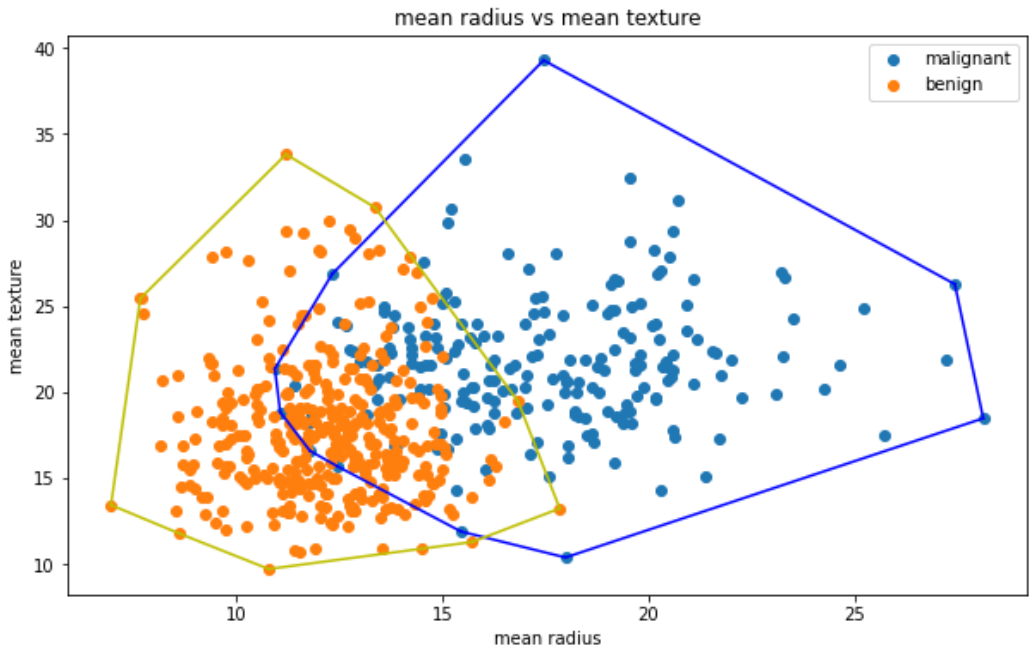
	mean radius	mean texture	mean perimeter	mean area	mean smoothness	mean compactness	mean concavity	mean concave points	mean symmetry	mean fractal dimension	...	worst texture	worst perimeter	worst area	worst smoothness	worst compactness	worst concavity	worst concave points	worst symmetry	worst fractal dimension	Target
0	17.99	10.38	122.80	1001.0	0.11840	0.27760	0.30010	0.14710	0.2419	0.07871	...	17.33	184.60	2019.0	0.16220	0.66560	0.7119	0.2654	0.4601	0.11890	0
1	20.57	17.77	132.90	1326.0	0.08474	0.07864	0.08690	0.07017	0.1812	0.05667	...	23.41	158.80	1956.0	0.12380	0.18660	0.2416	0.1860	0.2750	0.08902	0
2	19.69	21.25	130.00	1203.0	0.10960	0.15990	0.19740	0.12790	0.2069	0.05999	...	25.53	152.50	1709.0	0.14440	0.42450	0.4504	0.2430	0.3613	0.08758	0
3	11.42	20.38	77.58	386.1	0.14250	0.28390	0.24140	0.10520	0.2597	0.09744	...	26.50	98.87	567.7	0.20980	0.86630	0.6869	0.2575	0.6638	0.17300	0
4	20.29	14.34	135.10	1297.0	0.10030	0.13280	0.19800	0.10430	0.1809	0.05883	...	16.67	152.20	1575.0	0.13740	0.20500	0.4000	0.1625	0.2364	0.07678	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
564	21.56	22.39	142.00	1479.0	0.11100	0.11590	0.24390	0.13890	0.1726	0.05623	...	26.40	166.10	2027.0	0.14100	0.21130	0.4107	0.2216	0.2060	0.07115	0
565	20.13	28.25	131.20	1261.0	0.09780	0.10340	0.14400	0.09791	0.1752	0.05533	...	38.25	155.00	1731.0	0.11660	0.19220	0.3215	0.1628	0.2572	0.06637	0
566	16.60	28.08	108.30	858.1	0.08455	0.10230	0.09251	0.05302	0.1590	0.05648	...	34.12	126.70	1124.0	0.11390	0.30940	0.3403	0.1418	0.2218	0.07820	0
567	20.60	29.33	140.10	1265.0	0.11780	0.27700	0.35140	0.15200	0.2397	0.07016	...	39.42	184.60	1821.0	0.16500	0.86810	0.9387	0.2650	0.4087	0.12400	0
568	7.76	24.54	47.92	181.0	0.05263	0.04362	0.00000	0.00000	0.1587	0.05884	...	30.37	59.16	268.6	0.08996	0.06444	0.0000	0.0000	0.2871	0.07039	1

569 rows × 31 columns

Mean Radius vs Mean Texture

```
1  plt.figure(figsize = (10, 6))
2  colors = ['b', 'y', 'g', 'r', 'c', 'm', 'k']
3  plt.title(f'{breast_cancer.feature_names[0]} vs {breast_cancer.feature_names[1]}')
4  plt.xlabel(breast_cancer.feature_names[0])
5  plt.ylabel(breast_cancer.feature_names[1])
6  for i in range(len(breast_cancer.target_names)):
7      bucket = df2[df2['Target'] == i]
8      bucket = bucket.iloc[:,[0,1]].values
9      hull = myConvexHull(bucket)
10     plt.scatter(bucket[:, 0], bucket[:, 1], label=breast_cancer.target_names[i])
11     for simplex in hull.simplices:
12         plt.plot(bucket[simplex, 0], bucket[simplex, 1], colors[i%7])
13 plt.legend()
```

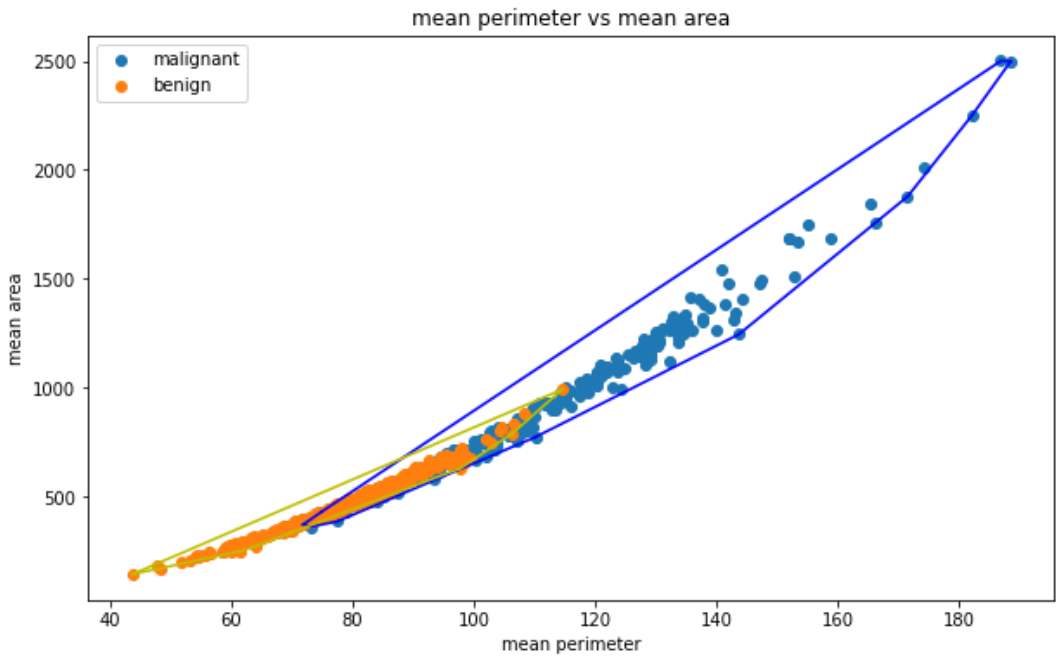
✓ 0.2s MagicPython



Mean Perimeter vs Mean Area

```
plt.figure(figsize = (10, 6))
colors = ['b', 'y', 'g', 'r', 'c', 'm', 'k']
plt.title(f'{breast_cancer.feature_names[2]} vs {breast_cancer.feature_names[3]}')
plt.xlabel(breast_cancer.feature_names[2])
plt.ylabel(breast_cancer.feature_names[3])
for i in range(len(breast_cancer.target_names)):
    bucket = df2[df2['Target'] == i]
    bucket = bucket.iloc[:,[2,3]].values
    hull = myConvexHull(bucket)
    plt.scatter(bucket[:, 0], bucket[:, 1], label=breast_cancer.target_names[i])
    for simplex in hull.simplices:
        plt.plot(bucket[simplex, 0], bucket[simplex, 1], colors[i%7])
plt.legend()
```

✓ 0.3s MagicPython


mean perimeter vs mean area
malignant
benign
mean area
mean perimeter
2500
2000
1500
1000
500
40
60
80
100
120
140
160
180

Tautan Repository Github

Berikut tautan yang dapat diakses untuk menuju ke kode program.
https://github.com/mhelmih/Tucil2_13520014

Poin	Ya	Tidak
1. Pustaka *myConvexHull* berhasil dibuat dan tidak ada kesalahan	✔	
2. *Convex hull* yang dihasilkan sudah benar	✔	
3. Pustaka *myConvexHull* dapat digunakan untuk menampilkan *convex hull* setiap label dengan warna yang berbeda	✔	
4. **Bonus**: program dapat menerima input dan menuliskan output untuk dataset lainnya.	✔	