

**LAPORAN TUGAS KECIL 2
IF2211 STRATEGI
ALGORITMA SEMESTER II
2022-2023**

**Pencarian Pasangan Titik Terdekat
3D dengan Algoritma Divide and
Conquer**

Disusun oleh:

Haidar Hamda

13521105



**PROGRAM STUDI TEKNIK
INFORMATIKA
SEKOLAH TEKNIK ELEKTRO DAN
INFORMATIKA
INSTITUT TEKNOLOGI BANDUNG 2023**

1. ALGORITMA

1.1 Algoritma Sorting

1. Pilih elemen larik terakhir sebagai pivot
2. Definisikan i dan j sebagai indeks pertama dari larik
3. Pertukarjan elemen larik[i] dengan larik[j] jika larik[i] \leq pivot, *increment j*
4. *Increment i*
5. Ulangi langkah 3-4 selama i < banyak nya elemen dalam larik
6. Pertukarkan elemen larik[j] dengan elemen terakhir larik

1.2 Algoritma Pencarian Sepasang Titik Terdekat

1. Pilih elemen larik terakhir sebagai pivot
2. Definisikan i dan j sebagai indeks pertama dari larik
3. Pertukarjan elemen larik[i] dengan larik[j] jika larik[i] \leq pivot, increment j
4. Increment i
5. Ulangi langkah 3-4 selama i < banyak nya elemen dalam larik
6. Pertukarkan elemen larik[j] dengan elemen terakhir larik

1.3 Algoritma Brute Force

1. Tetapkan jarak minimal dengan nilai tak terbatas
2. Iterasikan setiap titik dan bandingkan dengan titik lain yang memiliki indeks i+1
3. Jika jarak antar titik lebih rendah dari jarak minimal, simpan jarak antar titik dan pasangan titik tersebut

2. SOURCE CODE DALAM BAHASA RUBY

2.1 Main.rb

```
require_relative 'Algorithm.rb'
require_relative 'utils.rb'
require_relative 'plot.rb'

puts "number of points:"
n=gets.to_i
while n<2
  puts "ulangi input:"
  n=gets.to_i
end
puts "number of dimension:"
d=gets.to_i
while d<1
  puts "ulangi input:"
  d=gets.to_i
end
points= []
i=0
while i<n
  points.append([d.times.map{rand(-999.0..999.0)},i])
```

```
        i+=1
    end
    # points=points.sort_by{|item| item[0][0]}
    points=quickSortPoint(points,0,points.length-1)

    puts "divide and conquer:"
    startdq=Time.now
    pairs = divideNConquer(points)
    finishdq=Time.now
    print "distance: ",pairs[0]," between points: "
    printPoint(getPointById(points,pairs[1]))
    print " and "
    printPoint(getPointById(points,pairs[2]))
    print "\n"
    print "number of euclidean distance calculation: ",
    EuclidCounter.new.getCount-1,"\n"
    print "execution time: "
    print finishdq-startdq,"s\n\n"

    EuclidCounter.new.setToZero
    startbf=Time.now
    bf=bruteForce(points)
    finishbf=Time.now
    puts "brute force:"
    print "distance: ",bf[0]," between points: "
    printPoint(getPointById(points,bf[1]))
    print " and "
    printPoint(getPointById(points,bf[2]))
    print "\n"
    print "number of euclidean distance calculation: ",
    EuclidCounter.new.getCount-1,"\n"
    print "execution time: "
    print finishbf-startbf,"s\n"

    plotPoints(points,getPointById(points,pairs[1]),getPointBy
    Id(points,pairs[2]))
```

2.2 Utils.rb

```
def printPoint(point)
    i=0
    print "("
    while i<point[0].length()
        print point[0][i]
        if i!=point[0].length-1
            print ","
        end
    end
```

```
        i+=1
    end
    print ")"
end

def quickSortPoint(array, low, high)
    if low < high
        partitionIdx = partition(array, low, high)
        quickSortPoint(array, low, partitionIdx-1)
        quickSortPoint(array, partitionIdx+1, high)
    end
    return array
end

def partition(array, low, high)
    pivot = array[high][0][0]
    j = low
    i = low
    while j < high
        if array[j][0][0] <= pivot
            array[j], array[i] = array[i], array[j]
            i += 1
        end
        j += 1
    end
    array[i], array[high] = array[high], array[i]
    return i
end

def getPointById(points,id)
    return points.find{|item| item[1]==id}
end
```

2.3 Algorithm.rb

```
class EuclidCounter
    @@count=0
    def initialize
        @@count+=1
    end
    def getCount
        return @@count
    end
    def setToZero
        @@count=0
    end
end
```

```
def calculateDistance(p1,p2)
    i=0
    temp=[]
    while i<p1.length()
        temp.append((p1[i]-p2[i])**2)
        i+=1
    end
    p=EuclidCounter.new()
    return Math.sqrt(temp.sum)
end

def getPointInside(midPoint,points,delta)
    pointsInside = []
    i=0
    while i<points.length()
        if points[i][0][0]<midPoint+delta &&
points[i][0][0]>midPoint-delta
            pointsInside.append(points[i])
        end
        i+=1
    end
    return pointsInside
end

def bruteForce(points)
    min=[Float::MAX,-1,-1]
    i =0
    while i<points.length()
        j=i+1
        while j<points.length()
            d=calculateDistance(points[i][0],points[j][0])
            if d<min[0]
                min=[d,points[i][1],points[j][1]]
            end
            j+=1
        end
        i+=1
    end
    return min
end

def divideNConquer(points)
    if points.length()<=3
        return bruteForce(points)
    else
        rightPoints=points.slice(0,points.length/2)
```

```
leftPoints=points.slice(points.length/2,points.length())
rightPairs=divideNConquer(rightPoints)
leftPairs=divideNConquer(leftPoints)
if leftPairs[0]<rightPairs[0]
  closest=leftPairs
else
  closest=rightPairs
end

pointsInside=getPointInside(points[points.length/2][0][0],
points,closest[0])
  if !pointsInside.empty?
    insidePairs=bruteForce(pointsInside)
    if insidePairs[0]<closest[0]
      return insidePairs
    else
      return closest
    end
  else
    return closest
  end
end
end
```

2.4 Plot.rb

```
require 'gnuplot'

def plotPoints(points,p1,p2)
  if p1[0].length==3
    Gnuplot.open do |gp|
      Gnuplot::SPlot.new(gp) do |plot|
        plot.grid
        plot.xrange "[-1000:1000]"
        plot.yrange "[-1000:1000]"
        plot.zrange "[-1000:1000]"
        plot.xtics 250
        plot.ytics 250
        plot.ztics 250
        x=points.clone
        x.map{|item| item[0][0]}
        y=points.clone
        y.map{|item| item[0][1]}
        z=points.clone
        z.map{|item| item[0][2]}
        plot.xlabel "x"
        plot.ylabel "y"
```

```
plot.zlabel "z"
plot.data<<Gnuplot::DataSet.new([x,y,z]) do |ds|
  ds.with="points ps 1 pt 7 lc rgb 'blue'"
  ds.notitle
end
x2=[p1[0][0],p2[0][0]]
y2=[p1[0][1],p2[0][1]]
z2=[p1[0][2],p2[0][2]]
plot.data<<Gnuplot::DataSet.new([x2,y2,z2]) do
|ds1|
  ds1.with="points ps 1 pt 7 lc rgb 'red'"
  ds1.title= 'closest pair'
end
end
end
elsif p1[0].length==2
Gnuplot.open do |gp|
  Gnuplot::Plot.new(gp) do |plot|
    plot.grid
    plot.xrange "[-1000:1000]"
    plot.yrange "[-1000:1000]"
    plot.xtics 250
    plot.ytics 250
    x=points.clone
    x.map{|item| item[0][0]}
    y=points.clone
    y.map{|item| item[0][1]}
    plot.xlabel "x"
    plot.ylabel "y"
    plot.data<<Gnuplot::DataSet.new([x,y]) do |ds|
      ds.with="points ps 1 pt 7 lc rgb 'blue'"
      ds.notitle
    end
    x2=[p1[0][0],p2[0][0]]
    y2=[p1[0][1],p2[0][1]]
    plot.data<<Gnuplot::DataSet.new([x2,y2]) do |ds1|
      ds1.with="points ps 1 pt 7 lc rgb 'red'"
      ds1.title= 'closest pair'
    end
  end
end
end
end
end
```

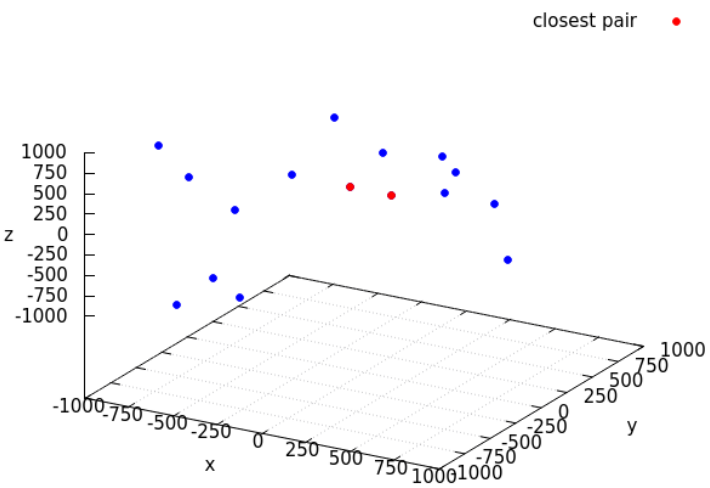
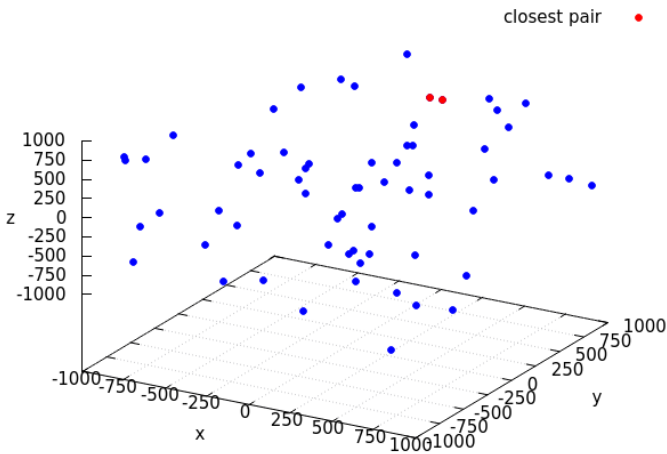
3. HASIL EKSEKUSI PROGRAM

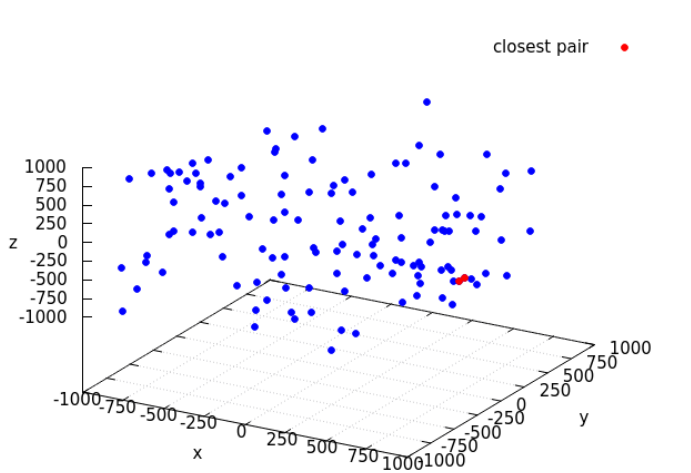
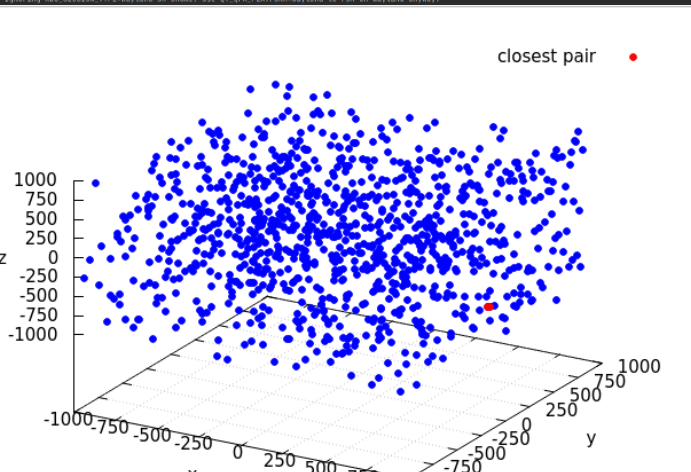
Pengujian eksekusi dilakukan pada computer dengan spesifikasi sebagai berikut:

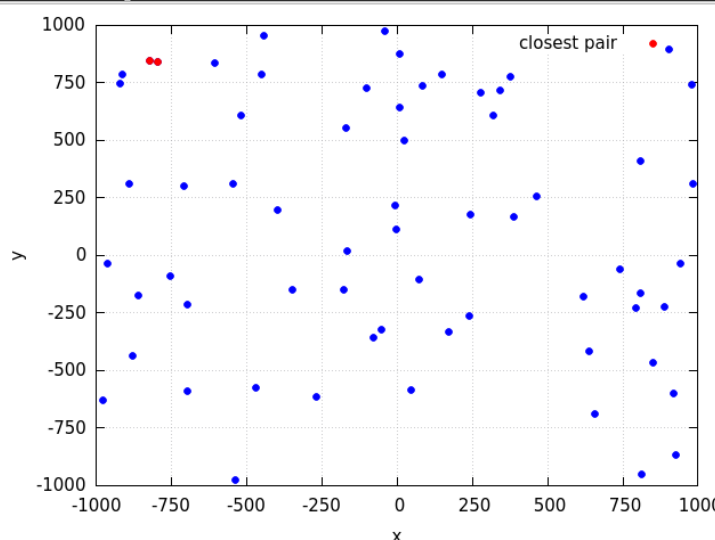
CPU: Intel Core i7-8550U

RAM: 8gb 2400MHz

Dengan sistem operasi: Red Hat Enterprise Linux 9

Banyak Titik (n)	Dimensi	Tangkapan Layar
16	3	<pre>[suisei@localhost src]\$ ruby main.rb number of points: 16 number of dimension: 3 divide and conquer: distance: 214.1616264560424 between points: (363.87174216160966, 769.0460924138125, 994.7236583831888) and (566.246824425418, 716.4723585970174, 948.3933844465607) number of euclidean distance calculation: 66 execution time: 9.080542323s brute force: distance: 214.1616264560424 between points: (363.87174216160966, 769.0460924138125, 994.7236583831888) and (566.246824425418, 716.4723585970174, 948.3933844465607) number of euclidean distance calculation: 120 execution time: 9.081393852s Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway.</pre> 
64	3	<pre>[suisei@localhost src]\$ ruby main.rb number of points: 64 number of dimension: 3 divide and conquer: distance: 92.44105942725816 between points: (171.64426239222462, 583.7409167304513, 881.6627136233881) and (217.186356429454, 643.7018283388894, 828.6347764926389) number of euclidean distance calculation: 915 execution time: 0.80224684ds brute force: distance: 92.44105942725816 between points: (171.64426239222462, 583.7409167304513, 881.6627136233881) and (217.186356429454, 643.7018283388894, 828.6347764926389) number of euclidean distance calculation: 2016 execution time: 0.808949782s Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway.</pre> 

128	3	<pre> [main@localhost src]\$ ruby main.rb number of points: 128 number of dimension: 3 divide and conquer: distance: 45.56278784208874 between points: (467.4379175097543,473.02743951673995,-986.0395822681752) and (505.89979634362726,471.50790432014765,-933.0376763186194) number of euclidean distance calculation: 2018 execution time: 0.0117126115 brute force: distance: 45.56278784208874 between points: (467.4379175097543,473.02743951673995,-986.0395822681752) and (505.89979634362726,471.50790432014765,-933.0376763186194) number of euclidean distance calculation: 8128 execution time: 0.0348188895 Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway. </pre> 
1000	3	<pre> [main@localhost src]\$ ruby main.rb number of points: 1000 number of dimension: 3 divide and conquer: distance: 12.119424241228019 between points: (990.8872351227863, 161.04719503877777, 898.56311760704496) and (990.4510689107368, 161.43013616726897, 407.56826521211297) number of euclidean distance calculation: 62285 execution time: 0.1345972635 brute force: distance: 12.119424241228019 between points: (990.8872351227863, 161.04719503877777, 898.56311760704496) and (990.4510689107368, 161.43013616726897, 407.56826521211297) number of euclidean distance calculation: 699589 execution time: 0.5436434579 Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway. </pre> 
64	4	<pre> [main@localhost src]\$ ruby main.rb number of points: 64 number of dimension: 4 divide and conquer: distance: 184.37602304362 between points: (-71.47398276559919,-844.831530195457,236.43121181629211,761.59194444847) and (-27.582841355612815,-955.8479318649415,118.5970815788669,908.1124446255813) number of euclidean distance calculation: 1615 execution time: 0.001228975 brute force: distance: 184.37602304362 between points: (-71.47398276559919,-844.831530195457,236.43121181629211,761.59194444847) and (-27.582841355612815,-955.8479318649415,118.5970815788669,908.1124446255813) number of euclidean distance calculation: 2016 execution time: 0.007027646 </pre>

64	2	<pre>[suisai@localhost src]\$ ruby main.rb number of points: 64 number of dimension: 2 divide and conquer: distance: 27.482152585027114 between points: (-821.1394177298171,845.1741849553836) and (-794.7801297551199,837.9748448397129) number of euclidean distance calculation: 298 execution time: 0.001578514s brute force: distance: 27.482152585027114 between points: (-821.1394177298171,845.1741849553836) and (-794.7801297551199,837.9748448397129) number of euclidean distance calculation: 2816 execution time: 0.006418063s Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway.</pre> 
Masukan tidak sesuai		<pre>[suisai@localhost src]\$ ruby main.rb number of points: 0 ulang input: -1 ulang input: d ulang input: a ulang input: a aja j ulang input: 10 number of dimension: a ulang input: -1 ulang input: a w d ulang input: 1 divide and conquer: distance: 5.87449445598304 between points: (722.4792512575216) and (728.3537457135046) number of euclidean distance calculation: 8 execution time: 0.000270545s</pre>

4. LAMPIRAN

4.1 Repository GitHub

https://github.com/haidarhamda/Tucil2_13521105

4.2 Tabel Ketercapaian Program

Poin	Ya	Tidak
1. Program berhasil dikompilasi tanpa ada kesalahan.	✓	
2. Program berhasil running	✓	

3. Program dapat menerima masukan dan dan menuliskan luaran.	✓	
4. Luaran program sudah benar (solusi closest pair benar)	✓	
5. Bonus 1 dikerjakan	✓	
6. Bonus 2 dikerjakan	✓	

Referensi

- [Closest Point Search in High Dimensions - Computer Vision and Pattern Recognition, 1996. Proceedings CVPR '96, 1996 IEEE Computer Society Co \(columbia.edu\)](#)
- [1976ShamosBentley.pdf \(cmu.edu\)](#)