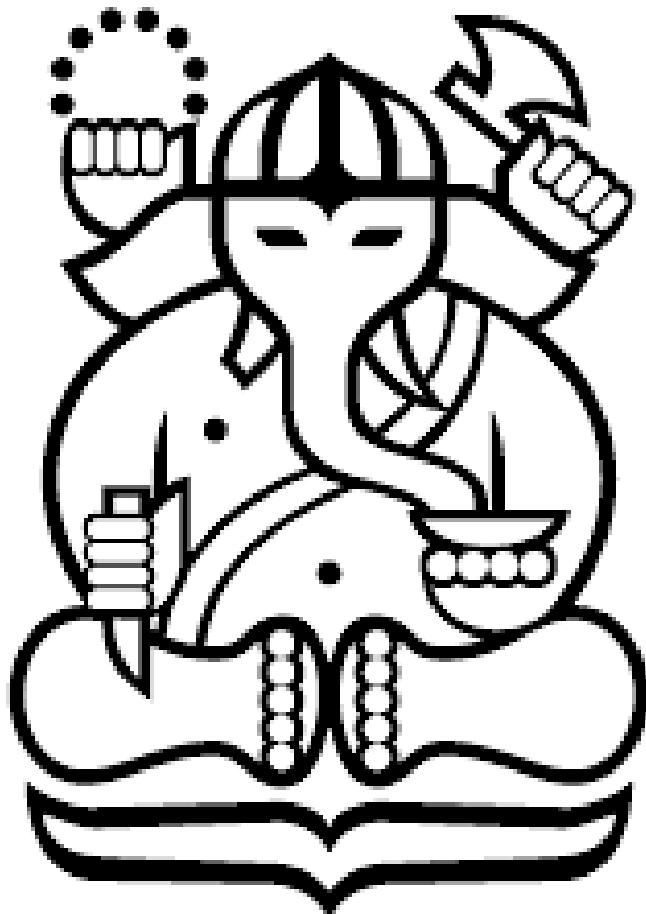


Laporan Tugas Besar 1

IF3170 Inteligensi Artifisial

Pencarian Solusi Diagonal Magic Cube dengan Local Search



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PROGRAM STUDI TEKNIK INFORMATIKA
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Daftar Isi

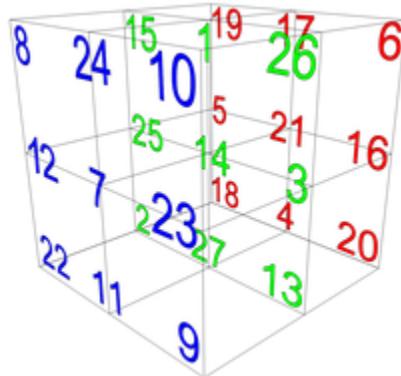
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Bab 1: Deskripsi Persoalaan

Diagonal magic cube merupakan kubus yang tersusun dari angka 1 hingga n^3 tanpa pengulangan dengan n adalah panjang sisi pada kubus tersebut. Angka-angka pada tersusun sedemikian rupa sehingga properti-properti berikut terpenuhi:

- Terdapat satu angka yang merupakan magic number dari kubus tersebut (Magic number tidak harus termasuk dalam rentang 1 hingga n^3 , magic number juga bukan termasuk ke dalam angka yang harus dimasukkan ke dalam kubus)
 - Jumlah angka-angka untuk setiap baris sama dengan magic number
 - Jumlah angka-angka untuk setiap kolom sama dengan magic number
 - Jumlah angka-angka untuk setiap tiang sama dengan magic number
 - Jumlah angka-angka untuk seluruh diagonal ruang pada kubus sama dengan magic number
 - Jumlah angka-angka untuk seluruh diagonal pada suatu potongan bidang dari kubus sama dengan magic number

Berikut ilustrasi dari potongan bidang yang ada pada suatu kubus berukuran 3:



Terdapat 9 potongan bidang, yaitu:

8 24 10	15 1 26	19 17 6
12 7 23	25 14 3	5 21 16
22 11 9	2 27 13	18 4 20
19 17 6	5 21 16	18 4 20
15 1 26	25 14 3	2 27 13
8 24 10	12 7 23	22 11 9
8 15 19	12 25 5	22 2 18
24 1 17	7 14 21	11 27 4
10 26 6	23 3 16	9 13 20

Diagonal yang dimaksud adalah yang dilingkari warna merah saja

Pada tugas ini, akan diselesaikan permasalahan Diagonal Magic Cube berukuran 5x5x5. Initial state dari suatu kubus adalah susunan angka 1 hingga 125 secara acak. Kemudian, tiap iterasi pada algoritma local search, langkah yang boleh dilakukan adalah menukar posisi dari 2 angka pada kubus tersebut (2 angka yang ditukar tidak harus bersebelahan). Khusus untuk genetic algorithm, boleh dilakukan penukaran posisi lebih dari 2 angka sekaligus dalam satu iterasi (tetapi hanya menukar posisi 2 angka saja juga diperbolehkan).

Bab 2: Pembahasan

2.1. Objective Function

Objective function yang dipilih adalah banyak rusuk dan diagonal *magic cube* yang memiliki jumlah nilai yang sama paling banyak.

2.2. Implementasi algoritma local search

Implementasi algoritma ini didasari pada kelas *magicCube*.

magic-cube.hpp

```
class magicCube {
public:
    vector<int> state;
    int value;

    magicCube(){
        for (int i = 1; i <= 125; i++) this->state.push_back(i);
        // Random seed
        srand(time(nullptr));
        random_shuffle(state.begin(), state.end());
        this->value = this->countValue();
    }
}
```

```

magicCube(vector<int> state) {
    this->state = state;
    this->value = this->countValue();
}

vector<int> makeNeighborState(int num1, int num2) {
    vector<int> neighborState = this->state;
    int temp = neighborState[num1];
    neighborState[num1] = neighborState[num2];
    neighborState[num2] = temp;
    return neighborState;
}

vector<int> makeRandomNeighborState() {
    int num1 = rand() % 124;
    int num2 = rand() % 124;
    while (num1 == num2) num2 = rand() % 124;
    return (this->makeNeighborState(num1, num2));
}

void switchStates(vector<int> newState) {
    this->state.swap(newState);
    this->value = this->countValue();
}

```

// Fungsi untuk menghitung value dari state sekarang
int countValue() {

...
}

// Fungsi untuk print state ke terminal
void printCube() {

...
}

Kelas hillClimb untuk algoritma Hill Climb.

hillclimb.hpp

```

class hillClimb {
public:
    magicCube magiccube;

    hillClimb(){
        this->magiccube = magicCube();
    }

    // Mengembalikan neighbor, yaitu successor dengan value terbesar
    magicCube highestValueNeighbor(magicCube current) {
        int maxvalue = 0, curvalue;
        magicCube neighbor = current,temp;

        for (int i = 0; i < 125; i++) {
            for (int j = i + 1; j < 125; j++) {
                vector<int> successor = current.state;
                swap(successor[i], successor[j]);
                temp.state = successor;
                curvalue = temp.countValue();
                temp.value = curvalue;
                if(temp.countValue() > maxvalue){
                    maxvalue = curvalue;
                    neighbor = temp;
                }
            }
        }
        return neighbor;
    }
}

```

2.2.1. Hill Climb : Steepest Ascent

```

void steepestAscent(){
    // Generate random cube
    random_shuffle(this->magiccube.state.begin(),
this->magiccube.state.end());
    this->magiccube.value = this->magiccube.countValue();

    // Print state awal
    cout << "State Awal :\n";
    this->magiccube.printCube();

    // Start timer
    auto start = high_resolution_clock::now();

```

```

// Fungsi Steepest Ascent
int iterasi = 0;
vector<int> plot;
bool peak = false;
plot.push_back(this->magiccube.value);
while(!peak) {
    magicCube neighbor = highestValueNeighbor(this->magiccube);
    if(neighbor.value <= this->magiccube.value){
        peak = true;
    } else {
        this->magiccube = neighbor;
    }
    iterasi++;
    plot.push_back(this->magiccube.value);
}

// Stop timer
auto end = high_resolution_clock::now();

// Hitung waktu
auto duration = duration_cast<milliseconds>(end - start);

// Print state akhir
cout << "State Akhir :\n";
this->magiccube.printCube();

// Print info
cout << "Nilai Akhir Objective Function : " <<
this->magiccube.value << endl;
cout << "Durasi : " << duration.count() / 1000.0 << " seconds"
<< endl;
cout << "Banyak Iterasi : " << iterasi << endl;

cout << plot[0];
for(int i=0;i<=iterasi;i++){
    cout << "," << plot[i];
} cout << endl;

// Delay
system("pause");
}

```

2.2.2. Hill Climb : with Sideways Move

```

void sideways(int maximumSidewaysMove) {
    // Generate random cube
    random_shuffle(this->magiccube.state.begin(),
this->magiccube.state.end());

```

```

this->magiccube.value = this->magiccube.countValue();

// Print state awal
cout << "State Awal :\n";
this->magiccube.printCube();

// Start timer
auto start = high_resolution_clock::now();

// Fungsi Steepest Ascent
int iterasi = 0, counterSideways;
vector<int> plot;
bool peak = false;
plot.push_back(this->magiccube.value);
while(!peak) {
    magicCube neighbor = highestValueNeighbor(this->magiccube);
    if(neighbor.value < this->magiccube.value){
        peak = true;
    } else {
        if(neighbor.value == this->magiccube.value){
            counterSideways++;
        } else {
            counterSideways = 0;
        }
        if(counterSideways == maximumSidewaysMove) {
            peak = true;
        } else {
            this->magiccube = neighbor;
        }
    }
    iterasi++;
    plot.push_back(this->magiccube.value);
}

// Stop timer
auto end = high_resolution_clock::now();

// Hitung waktu
auto duration = duration_cast<milliseconds>(end - start);

// Print state akhir
cout << "State Akhir :\n";
this->magiccube.printCube();

// Print info
cout << "Nilai Akhir Objective Function : " <<
this->magiccube.value << endl;
cout << "Durasi : " << duration.count() / 1000.0 << " seconds"
<< endl;
cout << "Banyak Iterasi : " << iterasi << endl;

```

```

cout << plot[0];
for(int i=0;i<=iterasi;i++) {
    cout << "," << plot[i];
} cout << endl;

// Delay
system("pause");
}

```

2.2.3. Hill Climb : Random Restart

```

void randomRestart(int maximumRestart) {
    int maxvalue = 0,restart;
    vector<int> iterasi;
    vector<vector<int>> plot;

    // Print state awal
    cout << "State Awal :\n";
    this->magiccube.printCube();

    // Start timer
    auto start = high_resolution_clock::now();

    for(restart=0;restart<maximumRestart;restart++) {
        // Generate random cube
        random_shuffle(this->magiccube.state.begin(),
this->magiccube.state.end());
        this->magiccube.value =
this->magiccube.countValue();
        // Fungsi Steepest Ascent
        int iterasii = 0;
        vector<int> plottemp;
        plottemp.clear();
        bool peak = false;
        plottemp.push_back(this->magiccube.value);
        while(!peak) {
            magicCube neighbor =
highestValueNeighbor(this->magiccube);
            if(neighbor.value <= this->magiccube.value) {
                peak = true;
            } else {
                this->magiccube = neighbor;
            }
            iterasii++;
            plottemp.push_back(this->magiccube.value);
        }
        plot.push_back(plottemp);
        iterasi.push_back(iterasii);
    }
}

```

```

        cout << "iterasi ke-" << restart+1 << endl;
        cout << plottemp[0];
        for(int i=1;i<=iterasii;i++){
            cout << "," << plottemp[i];
        } cout << endl;

        if(maxvalue < this->magiccube.value) {
            maxvalue = this->magiccube.value;
        }
    }

    // Stop timer
    auto end = high_resolution_clock::now();

    // Hitung waktu
    auto duration = duration_cast<milliseconds>(end -
start);

    // Print state akhir
    cout << "State Akhir :\n";
    this->magiccube.printCube();

    // Print info
    cout << "Nilai Akhir Objective Function : " <<
this->magiccube.value << endl;
    cout << "Durasi : " << duration.count() / 1000.0 << "
seconds" << endl;
    cout << "Iterasi per restart :\n";
    for(int i=0;i<restart;i++){
        cout << "restart-" << i+1 << " : " << iterasi[i] <<
endl;
    }

    for(int i=0;i<restart;i++){
        cout << "restart-" << i+1 << endl;
        int j=0;
        for(int plotting : plot[i]){
            cout << j << "," << plotting << endl;
            j++;
        }
    }

    cout << "Maximum value : " << maxvalue << endl;

    // Delay
    system("pause");
}

```

2.2.4. Hill Climb : Stochastic

```
void stochastic(int maximumMove) {
    // Generate random cube
    random_shuffle(this->magiccube.state.begin(),
this->magiccube.state.end());
    this->magiccube.value = this->magiccube.countValue();

    // Print state awal
    cout << "State Awal :\n";
    this->magiccube.printCube();

    // Start timer
    auto start = high_resolution_clock::now();

    // Fungsi Stochastic
    int iterasi = 0;
    vector<int> plot;
    bool peak = false;
    plot.push_back(this->magiccube.value);
    while(maximumMove--) {
        magicCube neighbor = this->magiccube;

        neighbor.switchStates(this->magiccube.makeRandomNeighborState());
        if(neighbor.value > this->magiccube.value) {
            this->magiccube = neighbor;
        }
        iterasi++;
        plot.push_back(this->magiccube.value);
    }

    // Stop timer
    auto end = high_resolution_clock::now();

    // Hitung waktu
    auto duration = duration_cast<milliseconds>(end - start);

    // Print state akhir
    cout << "State Akhir :\n";
    this->magiccube.printCube();

    // Print info
    cout << "Nilai Akhir Objective Function : " <<
this->magiccube.value << endl;
    cout << "Durasi : " << duration.count() / 1000.0 << " seconds"
<< endl;
    cout << "Banyak Iterasi : " << iterasi << endl;

    cout << plot[0];
    for(int i=0;i<=iterasi;i++){
        cout << "," << plot[i];
```

```
    } cout << endl;

    // Delay
    system("pause");
}
```

2.2.5. Simulated Annealing

Kelas simulated annealing pada simulated-annealing.hpp, dengan fungsi schedule berupa

$$T = 0.6^{t-1}$$

```
you, 24 minutes ago | + author (you)
class SimulatedAnnealing {
private:
    magicCube cube;
    double temperature;
    vector<int> plot;
    vector<double> plotexp;
    int freqStuck;

    double schedule(int t) {
        return pow(0.6,t-1);
    }
}
```

Algoritma Utama:

```
public:
    SimulatedAnnealing() : temperature(1.0), freqStuck(0) {}

    void run(int maxIterations) {
        plot.push_back(cube.value);
        for (int t = 1; t <= maxIterations; ++t) {
            temperature = schedule(t);
            if (temperature <= 0) break;

            magicCube successor = cube;
            successor.switchStates(cube.makeRandomNeighborState());
            int deltaE = successor.value - cube.value;

            if (deltaE > 0) {
                cube.switchStates(successor.state);
            } else {
                freqStuck++;
                double acceptanceProb;
                if (temperature <= 0) acceptanceProb = 0;
                else{
                    acceptanceProb = exp(deltaE / temperature);
                    if (acceptanceProb > 1) acceptanceProb = 1;
                }

                plotexp.push_back(acceptanceProb);
                if (((double)rand() / (double)RAND_MAX) < acceptanceProb) {
                    cube.switchStates(successor.state);
                }
            }
            plot.push_back(cube.value);
        }
    }
}
```

Kakas untuk algoritma utama:

```

void start(){
    // Clear terminal
    system("cls");

    // Print state awal
    cout << "State Awal :\n";
    cube.printCube();

    // Start timer
    auto start = high_resolution_clock::now();

    // Fungsi Simulated-Annealing
    this->run(1000);

    // Stop timer
    auto end = high_resolution_clock::now();

    // Hitung waktu
    auto duration = duration_cast<milliseconds>(end - start);

    // Print state akhir
    cout << "State Akhir :\n";
    this->cube.printCube();

    // Print info
    cout << "Nilai Akhir Objective Function : " << this->cube.value << endl;
    cout << "Durasi : " << duration.count() / 1000.0 << " seconds" << endl;
    cout << "Frekuensi Stuck : " << freqStuck << endl;
    cout << "Plot Objective Function : " << endl; printVectorInt(plot);
    cout << "Plot exp(deltaE/T) : " << endl; printVectorDouble(plotexp);
}

```

Isi main pada simmulated-annealing.cpp

```

#include "simmulated-annealing.hpp"

int main(){
    SimulatedAnnealing SA;

    system("cls");
    cout << "Algoritma Simmulated Annealing\n";
    SA.start();
    exit(0);
}

```

2.2.6. Genetic Algorithm

genetic-algorithm.hpp

```
#ifndef GENETICALGORITHM_HPP
#define GENETICALGORITHM_HPP

#include <bits/stdc++.h>
#include "magic-cube.hpp"
using namespace std;

class geneticAlgorithm {
private:
    vector<magicCube> population;
    int iterations;
    int popcount;

public:
    geneticAlgorithm(int i, int p);
    void initPopulation(magicCube origin, int count);
    int selection();
    vector<vector<int>> crossover(magicCube parent1, magicCube parent2);
    void mutate(magicCube* child);
    void go(int e);
    int bestIndividual();
    double meanValues();
};

#endif
```

genetic-algorithm.cpp

```
#include "genetic-algorithm.hpp"
#include <fstream>
using namespace std;

void printVec(vector<int> vec, int ex) {
    string filename = "max";
    filename.append(to_string(ex));
    ofstream maxFile(filename);

    // Write to the file
    for (int i=0; i<vec.size(); i++) {
        maxFile << vec[i] << ",";
    }
    maxFile << vec[124] << endl;
}

// Close the file
maxFile.close();
}
```

```

void printVecD(vector<double> vec, int ex) {
    string filename = "mean";
    filename.append(to_string(ex));
    ofstream meanFile(filename);
    // Write to the file
    for (int i=0; i<vec.size(); i++) {
        meanFile << vec[i] << ",";
    }
    meanFile << vec[124] << endl;

    // Close the file
    meanFile.close();
}

geneticAlgorithm::geneticAlgorithm(int i, int p) {
    magicCube origin = magicCube();
    this->iterations = i;
    this->popcount = p;
    this->initPopulation(origin, p);
    srand(time(NULL)); //setting seed
    cout << "Nilai Awal Objective Function: " << origin.value <<
endl;
    origin.printCube();
}

void geneticAlgorithm::initPopulation(magicCube origin, int count)
{
    vector<magicCube> popul;
    for (int i=0; i<count; i++)
popul.push_back(magicCube(origin.makeRandomNeighborState()));
    this->population = popul;
}

int geneticAlgorithm::selection() {
    double selector = static_cast <double> (rand()) / static_cast
<double> (RAND_MAX);
    double curval = 0;
    double sumvalues = 0;

    for (int i=0; i<popcount; i++) {
        sumvalues += population[i].value;
    }

    for (int i=0; i<popcount; i++) {
        curval += population[i].value/sumvalues;
        if (selector < curval) {
            return i;
        }
    }
    return popcount-1;
}

```

```

}

vector<vector<int>> geneticAlgorithm::crossover(magicCube parent1,
magicCube parent2) {
    int point = rand() % 124;

    vector<vector<int>> res;
    vector<int> child1;
    vector<int> child2;

    child1.insert(child1.begin(), parent1.state.begin(),
parent1.state.begin()+point);
    child1.insert(child1.end(), parent2.state.begin()+point,
parent2.state.end());
    res.push_back(child1);

    child2.insert(child2.begin(), parent2.state.begin(),
parent2.state.begin()+point);
    child2.insert(child2.end(), parent1.state.begin()+point,
parent1.state.end());
    res.push_back(child2);
    return res;
}

void geneticAlgorithm::mutate(magicCube* child) {
    double chance = static_cast <double> (rand()) / static_cast
<double> (RAND_MAX);
    if (chance > 0.95)
child->switchStates(child->makeRandomNeighborState());
}

void geneticAlgorithm::go(int exp) {
    // Start timer
    auto start = chrono::high_resolution_clock::now();

    //vector untuk menyimpan value per iterasi
    vector<int> maxVals;
    vector<double> meanVals;

    for (int i=0; i<this->iterations; i++) {
        int selection1 = this->selection();
        int selection2 = this->selection();
        while (selection2==selection1) selection2 =
this->selection();

        magicCube parent1 = this->population[selection1];
        magicCube parent2 = this->population[selection2];

        vector<vector<int>> cross = this->crossover(parent1,
parent2);
        magicCube child1 = magicCube(cross[0]);

```

```

        magicCube child2 = magicCube(cross[1]);

        this->mutate(&child1);
        this->mutate(&child2);

        this->population.push_back(child1);
        this->population.push_back(child2);
        this->popcount += 2;

maxVals.push_back(this->population[this->bestIndividual()].value);
meanVals.push_back(this->meanValues());
}
// Stop timer
auto end = chrono::high_resolution_clock::now();

// Hitung waktu
auto duration = chrono::duration_cast<chrono::milliseconds>(end
- start);
int best_idx = this->bestIndividual();
cout << "Nilai Akhir Objective Function : " <<
this->population[best_idx].value << endl;
this->population[best_idx].printCube();
cout << "Durasi : " << duration.count() / 1000.0 << " seconds"
<< endl;
cout << "Banyak Iterasi : " << this->iterations << endl;
printVec(maxVals, exp);
printVecD(meanVals, exp);
}

int geneticAlgorithm::bestIndividual() {
    int max = 0;
    int idx = 0;
    for (int i=1; i<this->popcount; i++) {
        if (this->population[i].value > max) {
            idx = i;
            max = this->population[i].value;
        }
    }
    return idx;
}

double geneticAlgorithm::meanValues() {
    double sum = 0;
    for (int i=1; i<this->popcount; i++)
sum+=this->population[i].value;
    return sum/popcount;
}

int main() {
    int iterations, size, experiment;

```

```
cout << "Masukkan angka eksperimen: ";
cin >> experiment;
cout << "Masukkan jumlah iterasi: ";
cin >> iterations;
cout << "Masukkan jumlah populasi awal: ";
cin >> size;
geneticAlgorithm genalg = geneticAlgorithm(iterations, size);
genalg.go(experiment);
}
```

2.3. Hasil Eksperimen dan Analisis

2.3.1. Eksperimen

- Hill Climb : Steepest Ascent

Percobaan 1

State Awal

052	004	007	055	002
/	/	/	/	/
081	013	033	114	051
/	/	/	/	/
119	014	083	088	023
/	/	/	/	/
018	044	053	025	012
/	/	/	/	/
041	024	091	068	054
029	098	082	016	- - - 022
/	/	/	/	/
093	020	080	112	- - 042
/	/	/	/	/
039	116	104	078	- 067
/	/	/	/	/
103	-028	-084	-122	- 070
/	/	/	/	/
090	035	005	064	077
060	006	086	063	- - - 019
/	/	/	/	/
101	-125	062	034	- - 061
/	/	/	/	/
045	027	071	049	- 087
/	/	/	/	/
056	-030	-059	-092	- 046
/	/	/	/	/
017	123	105	120	- 003
050	-038	-094	108	- - - 102
/	/	/	/	/
001	-076	-085	065	- - 124
/	/	/	/	/
008	-069	-073	-072	- 043
/	/	/	/	/
037	-113	-121	-117	- 074
/	/	/	/	/
089	-057	-115	079	- 096
026	010	099	109	- - - 110
/	/	/	/	/
047	-075	-040	106	- - 107
/	/	/	/	/
036	-032	-021	-009	- 031
/	/	/	/	/
100	-048	-058	-111	- 066
/	/	/	/	/
118	-097	-015	095	- 011

State Akhir

052	094	082	055	002
/	/	/	/	/
121	032	033	114	-051
/	/	/	/	/
119	014	107	088	-023
/	/	/	/	/
018	087	118	116	-012
/	/	/	/	/
041	039	011	006	-096
028	038	025	016	-022
/	/	/	/	/
081	020	021	112	-115
/	/	/	/	/
046	056	104	078	-067
/	/	/	/	/
103	-073	-054	122	-070
/	/	/	/	/
090	035	005	009	-077
060	068	086	063	-019
/	/	/	/	/
101	125	062	034	-029
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080	027	071	049	-044
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093	-030	-004	-092	-061
/	/	/	/	/
017	123	105	120	-003
050	036	059	108	-02
/	/	/	/	/
001	076	085	065	-124
/	/	/	/	/
008	069	024	072	-043
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037	-113	-010	-117	-074
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089	057	042	079	084
026	007	099	109	-110
/	/	/	/	/
047	075	040	106	-083
/	/	/	/	/
098	013	045	064	-031
/	/	/	/	/
100	-048	-058	-111	-066
/	/	/	/	/
053	097	015	095	091

**Nilai Akhir
Objective
Function**

37

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"><thead><tr><th>Jumlah Iterasi</th><th>Value</th></tr></thead><tbody><tr><td>1</td><td>3</td></tr><tr><td>2</td><td>5</td></tr><tr><td>3</td><td>7</td></tr><tr><td>4</td><td>9</td></tr><tr><td>5</td><td>11</td></tr><tr><td>6</td><td>12</td></tr><tr><td>7</td><td>13</td></tr><tr><td>8</td><td>14</td></tr><tr><td>9</td><td>15</td></tr><tr><td>10</td><td>16</td></tr><tr><td>11</td><td>17</td></tr><tr><td>12</td><td>18</td></tr><tr><td>13</td><td>19</td></tr><tr><td>14</td><td>20</td></tr><tr><td>15</td><td>21</td></tr><tr><td>16</td><td>22</td></tr><tr><td>17</td><td>23</td></tr><tr><td>18</td><td>24</td></tr><tr><td>19</td><td>25</td></tr><tr><td>20</td><td>26</td></tr><tr><td>21</td><td>27</td></tr><tr><td>22</td><td>28</td></tr><tr><td>23</td><td>29</td></tr><tr><td>24</td><td>30</td></tr><tr><td>25</td><td>31</td></tr><tr><td>26</td><td>32</td></tr><tr><td>27</td><td>33</td></tr><tr><td>28</td><td>34</td></tr><tr><td>29</td><td>35</td></tr><tr><td>30</td><td>36</td></tr></tbody></table>	Jumlah Iterasi	Value	1	3	2	5	3	7	4	9	5	11	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19	14	20	15	21	16	22	17	23	18	24	19	25	20	26	21	27	22	28	23	29	24	30	25	31	26	32	27	33	28	34	29	35	30	36
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Durasi	11.658 detik																																																														
Banyak Iterasi	28																																																														

Percobaan 2

State Awa

104	058	010	001	071
/	/	/	/	/
048	074	083	042	123
/	/	/	/	/
072	102	018	016	005
/	/	/	/	/
015	095	017	036	105
/	/	/	/	/
003	007	047	109	024
066	055	028	101	- - - 124
/	/	/	/	/
080	077	092	019	- - - 125
/	/	/	/	/
044	079	122	067	- 040
/	/	/	/	/
053	-014	065	120	064
/	/	/	/	/
054	115	069	022	041
057	025	097	085	- - - 032
/	/	/	/	/
056	081	073	011	- - - 026
/	/	/	/	/
082	068	021	103	- 051
/	/	/	/	/
089	-099	049	023	[110]
/	/	/	/	/
034	037	108	107	090
096	033	094	004	- - - 030
/	/	/	/	/
087	059	078	084	- - - 039
/	/	/	/	/
116	118	002	070	- 050
/	/	/	/	/
119	-031	088	093	[029]
/	/	/	/	/
035	091	111	114	020
086	063	027	043	- - - 060
/	/	/	/	/
052	121	009	062	- - - 013
/	/	/	/	/
075	061	038	045	- 100
/	/	/	/	/
098	-112	012	076	[117]
/	/	/	/	/
113	006	046	008	106

State Akhir

105	081	092	001	011
/	/	/	/	/
048	074	083	095	054
/	/	/	/	/
086	006	018	016	064
/	/	/	/	/
015	027	017	036	104
/	/	/	/	/
003	069	047	109	024
/	/	/	/	/
029	055	012	101	- - -124
/	/	/	/	/
093	077	010	019	- - -125
/	/	/	/	/
087	079	028	023	- - 040
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053	-014	-065	-120	005
/	/	/	/	/
072	-115	-007	022	041
/	/	/	/	/
057	025	058	085	- - -1032
/	/	/	/	/
108	090	073	071	- - -1026
/	/	/	/	/
078	068	021	103	- - 051
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089	-099	-049	-067	110
/	/	/	/	/
034	037	056	107	097
/	/	/	/	/
096	033	094	004	- - -1030
/	/	/	/	/
044	059	082	084	- - -1039
/	/	/	/	/
116	043	002	070	- - 050
/	/	/	/	/
119	-031	-088	-080	118
/	/	/	/	/
035	091	111	114	020
/	/	/	/	/
123	063	042	066	- - -1060
/	/	/	/	/
052	121	009	062	- - 013
/	/	/	/	/
106	061	122	045	- - 100
/	/	/	/	/
098	-112	-038	-076	117
/	/	/	/	/
113	102	046	008	075

Nilai Akhir Objektif Fungsi = 34

**Nilai Akhir
Objective
Function**

34

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"> <thead> <tr> <th>Jumlah Iterasi</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>1</td><td>3</td></tr> <tr><td>2</td><td>5</td></tr> <tr><td>3</td><td>7</td></tr> <tr><td>4</td><td>9</td></tr> <tr><td>5</td><td>10</td></tr> <tr><td>6</td><td>12</td></tr> <tr><td>7</td><td>13</td></tr> <tr><td>8</td><td>14</td></tr> <tr><td>9</td><td>15</td></tr> <tr><td>10</td><td>16</td></tr> <tr><td>11</td><td>17</td></tr> <tr><td>12</td><td>18</td></tr> <tr><td>13</td><td>19</td></tr> <tr><td>14</td><td>20</td></tr> <tr><td>15</td><td>21</td></tr> <tr><td>16</td><td>22</td></tr> <tr><td>17</td><td>24</td></tr> <tr><td>18</td><td>25</td></tr> <tr><td>19</td><td>26</td></tr> <tr><td>20</td><td>27</td></tr> <tr><td>21</td><td>28</td></tr> <tr><td>22</td><td>29</td></tr> <tr><td>23</td><td>30</td></tr> <tr><td>24</td><td>31</td></tr> <tr><td>25</td><td>32</td></tr> <tr><td>26</td><td>33</td></tr> <tr><td>27</td><td>34</td></tr> </tbody> </table>	Jumlah Iterasi	Value	1	3	2	5	3	7	4	9	5	10	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19	14	20	15	21	16	22	17	24	18	25	19	26	20	27	21	28	22	29	23	30	24	31	25	32	26	33	27	34
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27	34																																																								
Durasi	9.968																																																								
Banyak Iterasi	27																																																								

Percobaan 3

State Awal

084	015	094	055	011
/	/	/	/	/
023	101	024	081	112
/	/	/	/	/
051	089	103	093	119
/	/	/	/	/
054	036	053	019	097
/	/	/	/	/
118	025	061	109	069
/	/	/	/	/
057	021	044	120	- - - 083
/	/	/	/	/
071	105	078	076	- - - 007
/	/	/	/	/
067	074	095	080	- - 075
/	/	/	/	/
017	020	099	123	056
/	/	/	/	/
124	041	004	088	102
/	/	/	/	/
008	048	027	010	- - - 028
/	/	/	/	/
121	006	038	050	- - - 039
/	/	/	/	/
064	046	040	018	- - 035
/	/	/	/	/
001	087	079	002	063
/	/	/	/	/
108	030	085	009	116
/	/	/	/	/
047	022	070	060	- - - 096
/	/	/	/	/
049	043	062	033	- - - 029
/	/	/	/	/
100	066	082	032	- - 077
/	/	/	/	/
104	117	106	026	016
/	/	/	/	/
086	042	111	114	098
/	/	/	/	/
031	068	072	045	- - - 005
/	/	/	/	/
090	125	073	003	- - - 092
/	/	/	/	/
113	122	012	052	- - 034
/	/	/	/	/
059	058	013	065	107
/	/	/	/	/
037	110	115	091	014

State Akhir

058	015	072	055	066
/	/	/	/	/
085	101	123	104	099
/	/	/	/	/
051	089	037	014	075
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054	036	094	019	063
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023	025	108	074	069
057	021	044	120	- - - 024
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047	011	125	076	- - 007
/	/	/	/	/
116	109	095	016	- 077
/	/	/	/	/
071	084	062	083	056
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124	041	086	088	102
008	113	027	090	- - - 028
/	/	/	/	/
121	006	038	050	- - 039
/	/	/	/	/
064	046	040	018	- 035
/	/	/	/	/
001	087	079	002	097
/	/	/	/	/
061	048	118	009	067
017	022	070	060	- - - 096
/	/	/	/	/
049	043	112	033	- - 029
/	/	/	/	/
005	105	082	032	- 045
/	/	/	/	/
081	117	106	026	093
/	/	/	/	/
114	042	111	004	098
031	068	053	119	- - - 100
/	/	/	/	/
010	078	073	003	- - 092
/	/	/	/	/
030	122	012	052	- 034
/	/	/	/	/
059	020	013	065	107
/	/	/	/	/
103	110	115	091	080

Nilai Akhir
Objective
Function

37

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"> <thead> <tr> <th>Jumlah Iterasi</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>1</td><td>3</td></tr> <tr><td>2</td><td>4</td></tr> <tr><td>3</td><td>5</td></tr> <tr><td>4</td><td>6</td></tr> <tr><td>5</td><td>7</td></tr> <tr><td>6</td><td>8</td></tr> <tr><td>7</td><td>9</td></tr> <tr><td>8</td><td>10</td></tr> <tr><td>9</td><td>12</td></tr> <tr><td>10</td><td>13</td></tr> <tr><td>11</td><td>14</td></tr> <tr><td>12</td><td>15</td></tr> <tr><td>13</td><td>16</td></tr> <tr><td>14</td><td>17</td></tr> <tr><td>15</td><td>18</td></tr> <tr><td>16</td><td>19</td></tr> <tr><td>17</td><td>20</td></tr> <tr><td>18</td><td>21</td></tr> <tr><td>19</td><td>22</td></tr> <tr><td>20</td><td>23</td></tr> <tr><td>21</td><td>24</td></tr> <tr><td>22</td><td>25</td></tr> <tr><td>23</td><td>26</td></tr> <tr><td>24</td><td>27</td></tr> <tr><td>25</td><td>28</td></tr> <tr><td>26</td><td>29</td></tr> <tr><td>27</td><td>30</td></tr> <tr><td>28</td><td>31</td></tr> <tr><td>29</td><td>32</td></tr> <tr><td>30</td><td>33</td></tr> <tr><td>31</td><td>34</td></tr> <tr><td>32</td><td>35</td></tr> <tr><td>33</td><td>36</td></tr> </tbody> </table>	Jumlah Iterasi	Value	1	3	2	4	3	5	4	6	5	7	6	8	7	9	8	10	9	12	10	13	11	14	12	15	13	16	14	17	15	18	16	19	17	20	18	21	19	22	20	23	21	24	22	25	23	26	24	27	25	28	26	29	27	30	28	31	29	32	30	33	31	34	32	35	33	36
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Banyak Iterasi	34																																																																				

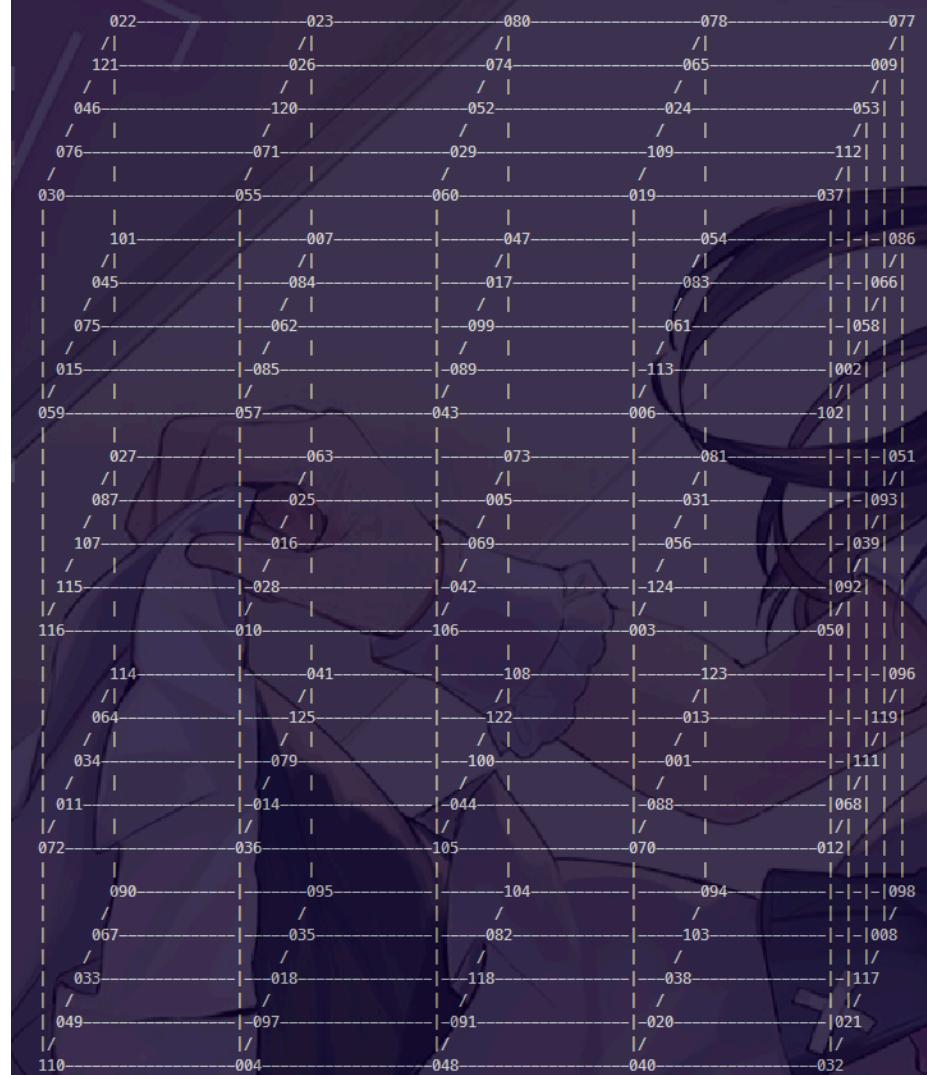
- Hill Climb : with Sideways Move

Percobaan 1

State Awal

022	010	110	078	077
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036	026	028	074	009
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118	106	052	024	053
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076	089	029	054	112
/	/	/	/	/
030	060	055	019	037
070	071	116	109	- - - 061
/	/	/	/	/
121	084	017	083	- - 087
/	/	/	/	/
075	062	099	012	- 006
/	/	/	/	/
015	085	007	113	002
/	/	/	/	/
059	057	043	101	102
124	063	073	081	- - - 051
/	/	/	/	/
066	025	005	031	- - 050
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107	020	069	092	- 039
/	/	/	/	/
115	065	042	027	056
/	/	/	/	/
046	023	120	122	018
098	041	008	123	- - - 096
/	/	/	/	/
064	125	003	013	- - 119
/	/	/	/	/
034	079	100	001	- 093
/	/	/	/	/
011	014	044	088	068
/	/	/	/	/
072	045	105	114	058
090	097	104	094	- - - 086
/	/	/	/	/
067	035	082	103	- - 108
/	/	/	/	/
033	111	047	080	- 117
/	/	/	/	/
049	038	091	016	021
/	/	/	/	/
095	004	048	040	032

State Akhir



Nilai Akhir
Objective
Function

42

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026	120	014	044	- - - 066
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038	106	018	081	- - - 027
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109	102	117	072	- [022]
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091	004	083	092	118
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071	121	098	101	052

Nilai Akhir
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Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"> <thead> <tr> <th>Jumlah Iterasi</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>0</td><td>3</td></tr> <tr><td>1</td><td>5</td></tr> <tr><td>2</td><td>6</td></tr> <tr><td>3</td><td>7</td></tr> <tr><td>4</td><td>8</td></tr> <tr><td>5</td><td>9</td></tr> <tr><td>6</td><td>10</td></tr> <tr><td>7</td><td>11</td></tr> <tr><td>8</td><td>12</td></tr> <tr><td>9</td><td>13</td></tr> <tr><td>10</td><td>14</td></tr> <tr><td>11</td><td>15</td></tr> <tr><td>12</td><td>16</td></tr> <tr><td>13</td><td>17</td></tr> <tr><td>14</td><td>18</td></tr> <tr><td>15</td><td>19</td></tr> <tr><td>16</td><td>20</td></tr> <tr><td>17</td><td>21</td></tr> <tr><td>18</td><td>22</td></tr> <tr><td>19</td><td>23</td></tr> <tr><td>20</td><td>24</td></tr> <tr><td>21</td><td>25</td></tr> <tr><td>22</td><td>26</td></tr> <tr><td>23</td><td>27</td></tr> <tr><td>24</td><td>28</td></tr> <tr><td>25</td><td>29</td></tr> <tr><td>26</td><td>30</td></tr> <tr><td>27</td><td>31</td></tr> <tr><td>28</td><td>32</td></tr> <tr><td>29</td><td>33</td></tr> <tr><td>30</td><td>34</td></tr> <tr><td>31</td><td>35</td></tr> <tr><td>32</td><td>36</td></tr> <tr><td>33</td><td>37</td></tr> <tr><td>34</td><td>38</td></tr> <tr><td>35</td><td>39</td></tr> <tr><td>36</td><td>39</td></tr> <tr><td>37</td><td>39</td></tr> <tr><td>38</td><td>39</td></tr> <tr><td>39</td><td>39</td></tr> <tr><td>40</td><td>39</td></tr> <tr><td>41</td><td>39</td></tr> <tr><td>42</td><td>39</td></tr> <tr><td>43</td><td>39</td></tr> <tr><td>44</td><td>39</td></tr> <tr><td>45</td><td>39</td></tr> <tr><td>46</td><td>39</td></tr> <tr><td>47</td><td>39</td></tr> <tr><td>48</td><td>39</td></tr> <tr><td>49</td><td>39</td></tr> <tr><td>50</td><td>39</td></tr> <tr><td>51</td><td>39</td></tr> <tr><td>52</td><td>39</td></tr> <tr><td>53</td><td>39</td></tr> <tr><td>54</td><td>39</td></tr> <tr><td>55</td><td>39</td></tr> <tr><td>56</td><td>39</td></tr> <tr><td>57</td><td>39</td></tr> <tr><td>58</td><td>39</td></tr> <tr><td>59</td><td>39</td></tr> <tr><td>60</td><td>39</td></tr> <tr><td>61</td><td>39</td></tr> <tr><td>62</td><td>39</td></tr> <tr><td>63</td><td>39</td></tr> <tr><td>64</td><td>39</td></tr> <tr><td>65</td><td>39</td></tr> <tr><td>66</td><td>39</td></tr> <tr><td>67</td><td>39</td></tr> <tr><td>68</td><td>39</td></tr> <tr><td>69</td><td>39</td></tr> <tr><td>70</td><td>39</td></tr> <tr><td>71</td><td>39</td></tr> <tr><td>72</td><td>39</td></tr> <tr><td>73</td><td>39</td></tr> <tr><td>74</td><td>39</td></tr> <tr><td>75</td><td>39</td></tr> <tr><td>76</td><td>39</td></tr> <tr><td>77</td><td>39</td></tr> <tr><td>78</td><td>39</td></tr> <tr><td>79</td><td>39</td></tr> <tr><td>80</td><td>39</td></tr> <tr><td>81</td><td>39</td></tr> <tr><td>82</td><td>39</td></tr> <tr><td>83</td><td>39</td></tr> <tr><td>84</td><td>39</td></tr> <tr><td>85</td><td>39</td></tr> <tr><td>86</td><td>39</td></tr> <tr><td>87</td><td>39</td></tr> <tr><td>88</td><td>39</td></tr> <tr><td>89</td><td>39</td></tr> <tr><td>90</td><td>39</td></tr> <tr><td>91</td><td>39</td></tr> <tr><td>92</td><td>39</td></tr> <tr><td>93</td><td>39</td></tr> <tr><td>94</td><td>39</td></tr> <tr><td>95</td><td>39</td></tr> <tr><td>96</td><td>39</td></tr> <tr><td>97</td><td>39</td></tr> <tr><td>98</td><td>39</td></tr> <tr><td>99</td><td>39</td></tr> <tr><td>100</td><td>39</td></tr> </tbody> </table>	Jumlah Iterasi	Value	0	3	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	13	10	14	11	15	12	16	13	17	14	18	15	19	16	20	17	21	18	22	19	23	20	24	21	25	22	26	23	27	24	28	25	29	26	30	27	31	28	32	29	33	30	34	31	35	32	36	33	37	34	38	35	39	36	39	37	39	38	39	39	39	40	39	41	39	42	39	43	39	44	39	45	39	46	39	47	39	48	39	49	39	50	39	51	39	52	39	53	39	54	39	55	39	56	39	57	39	58	39	59	39	60	39	61	39	62	39	63	39	64	39	65	39	66	39	67	39	68	39	69	39	70	39	71	39	72	39	73	39	74	39	75	39	76	39	77	39	78	39	79	39	80	39	81	39	82	39	83	39	84	39	85	39	86	39	87	39	88	39	89	39	90	39	91	39	92	39	93	39	94	39	95	39	96	39	97	39	98	39	99	39	100	39
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074	021	084	053	065
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013	029	026	037	002
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011	025	098	044	094
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State Akhir

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**Nilai Akhir
Objective
Function**

32

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"> <thead> <tr> <th>Jumlah Iterasi</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>0</td><td>3</td></tr> <tr><td>1</td><td>5</td></tr> <tr><td>2</td><td>6</td></tr> <tr><td>3</td><td>7</td></tr> <tr><td>4</td><td>8</td></tr> <tr><td>5</td><td>9</td></tr> <tr><td>6</td><td>10</td></tr> <tr><td>7</td><td>11</td></tr> <tr><td>8</td><td>12</td></tr> <tr><td>9</td><td>13</td></tr> <tr><td>10</td><td>14</td></tr> <tr><td>11</td><td>15</td></tr> <tr><td>12</td><td>16</td></tr> <tr><td>13</td><td>17</td></tr> <tr><td>14</td><td>18</td></tr> <tr><td>15</td><td>19</td></tr> <tr><td>16</td><td>20</td></tr> <tr><td>17</td><td>21</td></tr> <tr><td>18</td><td>22</td></tr> <tr><td>19</td><td>23</td></tr> <tr><td>20</td><td>24</td></tr> <tr><td>21</td><td>25</td></tr> <tr><td>22</td><td>26</td></tr> <tr><td>23</td><td>27</td></tr> <tr><td>24</td><td>28</td></tr> <tr><td>25</td><td>29</td></tr> <tr><td>26</td><td>31</td></tr> <tr><td>27</td><td>31.5</td></tr> <tr><td>28</td><td>31.5</td></tr> <tr><td>29</td><td>31.5</td></tr> <tr><td>30</td><td>31.5</td></tr> <tr><td>31</td><td>31.5</td></tr> <tr><td>32</td><td>31.5</td></tr> <tr><td>33</td><td>31.5</td></tr> <tr><td>34</td><td>31.5</td></tr> <tr><td>35</td><td>31.5</td></tr> <tr><td>36</td><td>31.5</td></tr> <tr><td>37</td><td>31.5</td></tr> <tr><td>38</td><td>31.5</td></tr> <tr><td>39</td><td>31.5</td></tr> <tr><td>40</td><td>31.5</td></tr> <tr><td>41</td><td>31.5</td></tr> <tr><td>42</td><td>31.5</td></tr> <tr><td>43</td><td>31.5</td></tr> <tr><td>44</td><td>31.5</td></tr> <tr><td>45</td><td>31.5</td></tr> <tr><td>46</td><td>31.5</td></tr> <tr><td>47</td><td>31.5</td></tr> <tr><td>48</td><td>31.5</td></tr> <tr><td>49</td><td>31.5</td></tr> <tr><td>50</td><td>31.5</td></tr> <tr><td>51</td><td>31.5</td></tr> <tr><td>52</td><td>31.5</td></tr> <tr><td>53</td><td>31.5</td></tr> <tr><td>54</td><td>31.5</td></tr> <tr><td>55</td><td>31.5</td></tr> <tr><td>56</td><td>31.5</td></tr> <tr><td>57</td><td>31.5</td></tr> <tr><td>58</td><td>31.5</td></tr> <tr><td>59</td><td>31.5</td></tr> <tr><td>60</td><td>31.5</td></tr> <tr><td>61</td><td>31.5</td></tr> <tr><td>62</td><td>31.5</td></tr> <tr><td>63</td><td>31.5</td></tr> <tr><td>64</td><td>31.5</td></tr> <tr><td>65</td><td>31.5</td></tr> <tr><td>66</td><td>31.5</td></tr> <tr><td>67</td><td>31.5</td></tr> </tbody> </table>	Jumlah Iterasi	Value	0	3	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	13	10	14	11	15	12	16	13	17	14	18	15	19	16	20	17	21	18	22	19	23	20	24	21	25	22	26	23	27	24	28	25	29	26	31	27	31.5	28	31.5	29	31.5	30	31.5	31	31.5	32	31.5	33	31.5	34	31.5	35	31.5	36	31.5	37	31.5	38	31.5	39	31.5	40	31.5	41	31.5	42	31.5	43	31.5	44	31.5	45	31.5	46	31.5	47	31.5	48	31.5	49	31.5	50	31.5	51	31.5	52	31.5	53	31.5	54	31.5	55	31.5	56	31.5	57	31.5	58	31.5	59	31.5	60	31.5	61	31.5	62	31.5	63	31.5	64	31.5	65	31.5	66	31.5	67	31.5
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Banyak Iterasi	67																																																																																																																																										
Parameter Maksimum	40																																																																																																																																										

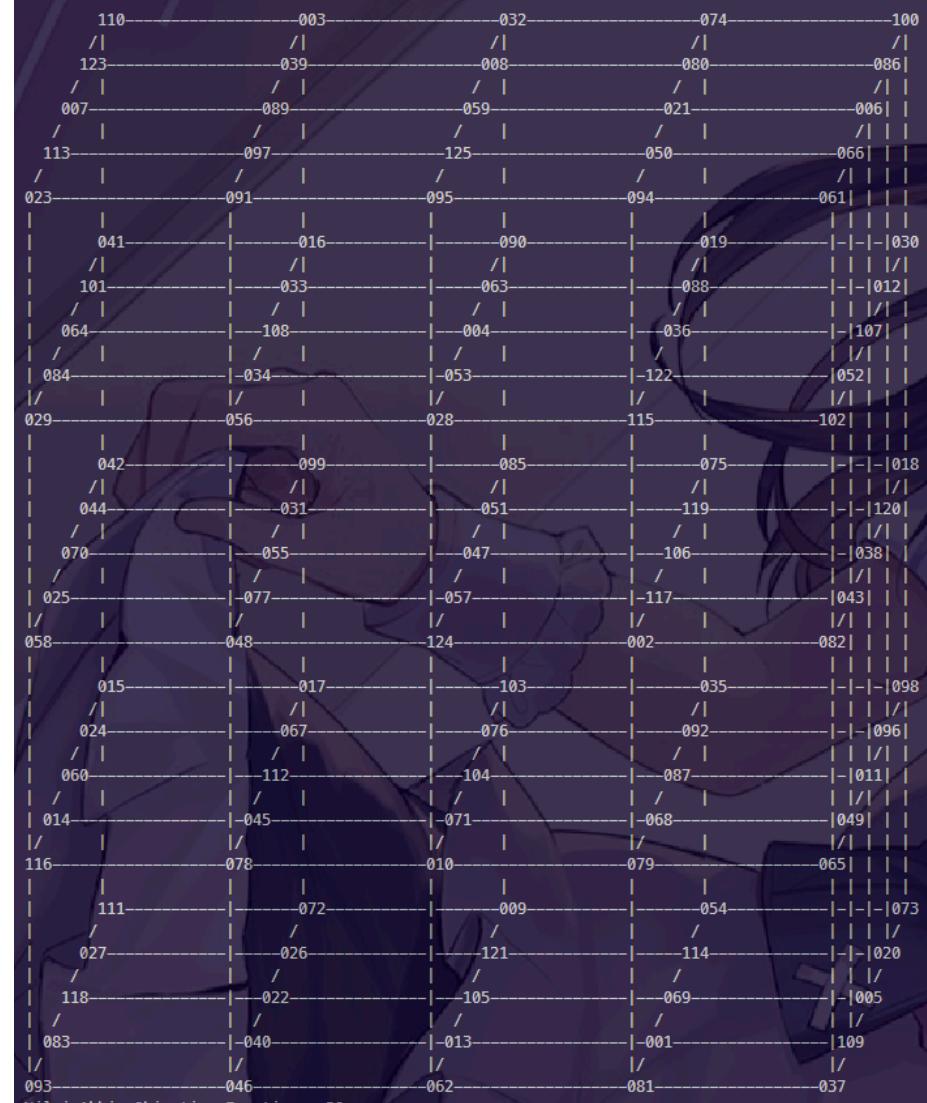
- Hill Climb : Random Restart

Percobaan 1

State Awal

100	039	055	083	109
/	/	/	/	/
014	120	051	108	034
/	/	/	/	/
123	092	073	020	078
/	/	/	/	/
106	053	097	018	112
/	/	/	/	/
043	012	110	001	113
122	030	107	003	- - - 124
/	/	/	/	/
103	038	088	036	- - 121
/	/	/	/	/
008	026	085	025	- 052
/	/	/	/	/
067	-056	-031	-045	094
/	/	/	/	/
086	064	075	057	015
079	049	063	119	- - - 076
/	/	/	/	/
021	069	101	096	- - 099
/	/	/	/	/
125	027	058	095	- 081
/	/	/	/	/
074	-007	-084	-006	065
/	/	/	/	/
013	029	023	070	002
080	-105	028	111	- - - 062
/	/	/	/	/
011	087	098	044	- - 016
/	/	/	/	/
117	046	091	061	- 071
/	/	/	/	/
033	-032	-060	-047	022
/	/	/	/	/
050	116	009	019	010
005	017	089	042	- - - 082
/	/	/	/	/
041	024	048	102	- 072
/	/	/	/	/
040	068	059	115	- 104
/	/	/	/	/
054	-066	-114	-090	093
/	/	/	/	/
077	118	004	037	035

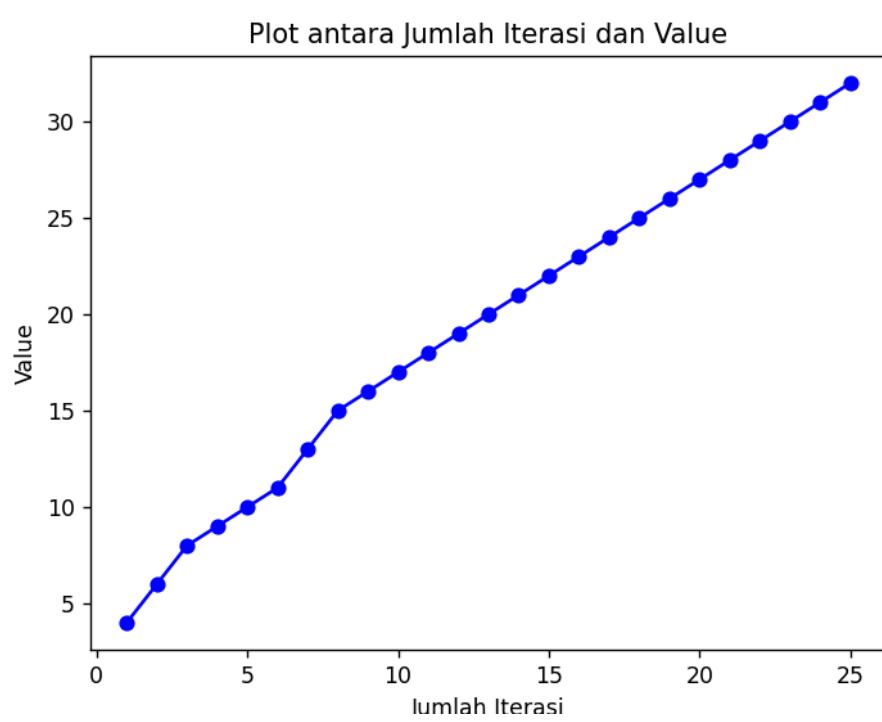
State Akhir



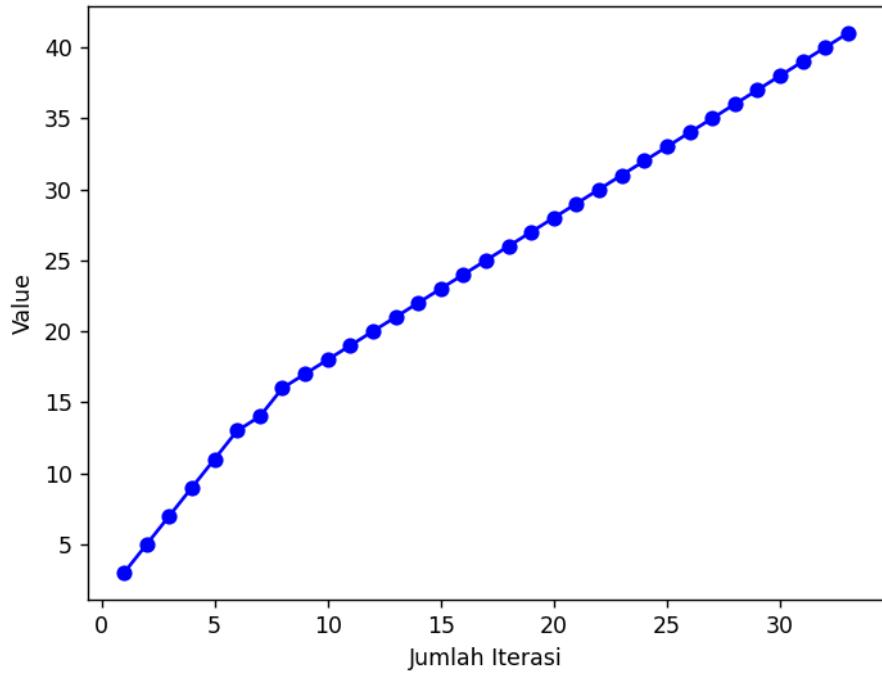
**Nilai Akhir
Objective
Function**

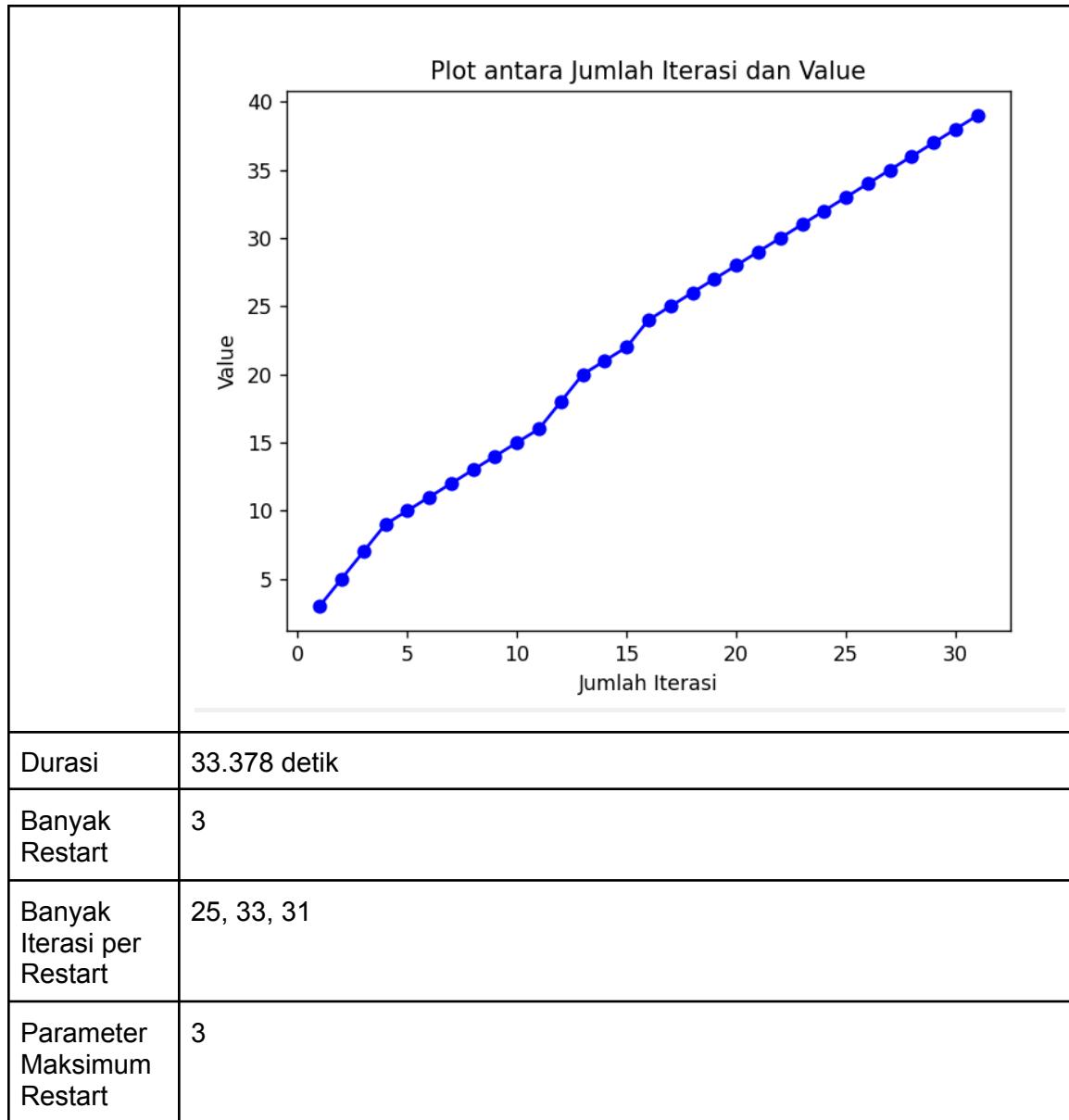
39

Plot



Plot antara Jumlah Iterasi dan Value





Percobaan 2

State Awal

110	003	032	074	100
/	/	/	/	/
123	039	008	080	086
/	/	/	/	/
007	089	059	021	006
/	/	/	/	/
113	097	125	050	066
/	/	/	/	/
023	091	095	094	061
041	016	090	019	-030
/	/	/	/	/
101	033	063	088	-012
/	/	/	/	/
064	108	004	036	-107
/	/	/	/	/
084	034	053	122	052
/	/	/	/	/
029	056	028	115	102
042	099	085	075	-018
/	/	/	/	/
044	031	051	119	-120
/	/	/	/	/
070	055	047	106	-038
/	/	/	/	/
025	077	057	117	043
/	/	/	/	/
058	048	124	002	082
015	017	103	035	-098
/	/	/	/	/
024	067	076	092	-096
/	/	/	/	/
060	112	104	087	-011
/	/	/	/	/
014	045	071	068	049
/	/	/	/	/
116	078	010	079	065
111	072	009	054	-073
/	/	/	/	/
027	026	121	114	-020
/	/	/	/	/
118	022	105	069	-005
/	/	/	/	/
083	040	013	001	109
/	/	/	/	/
093	046	062	081	037

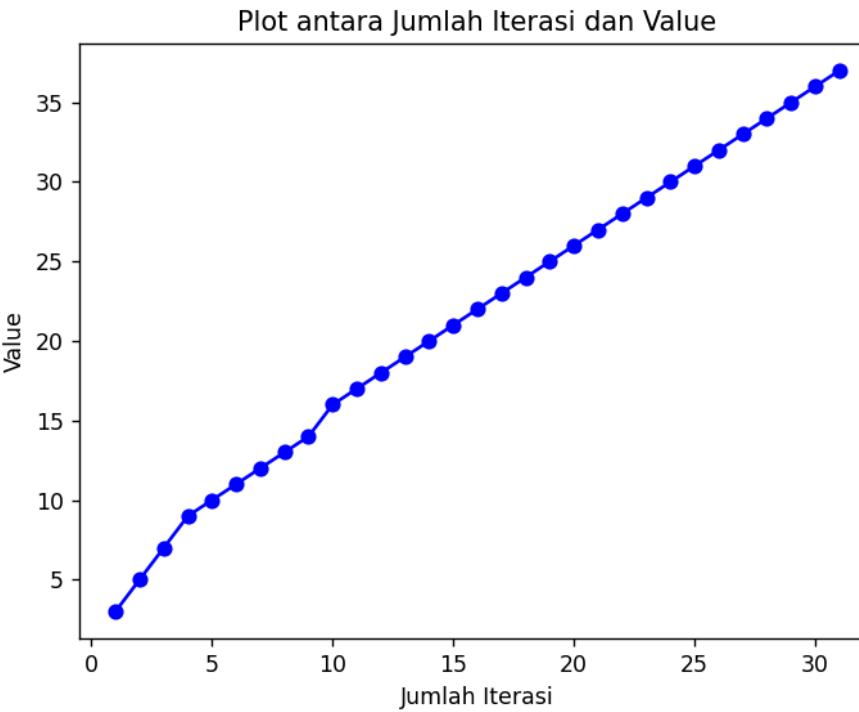
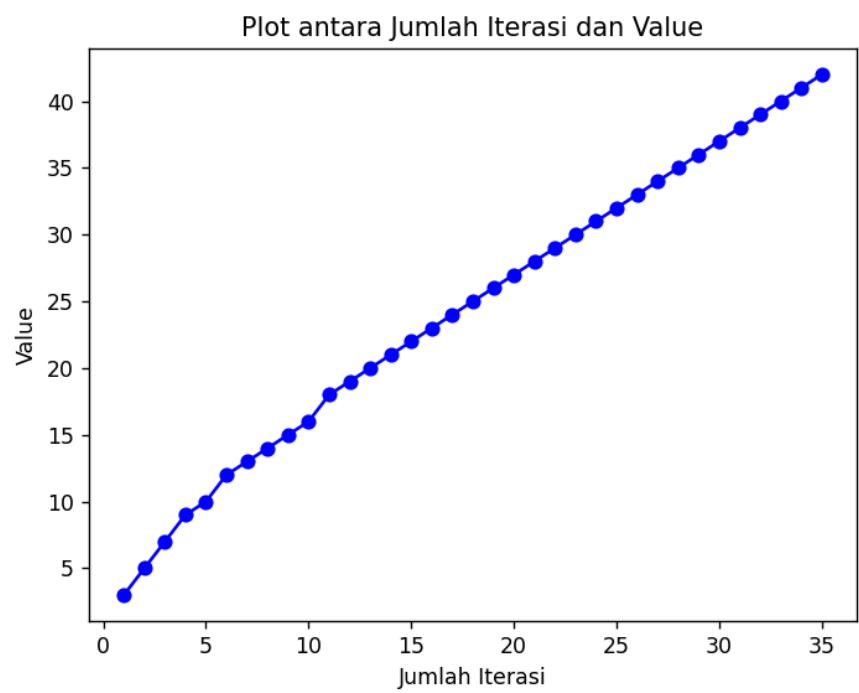
State Akhir

043	077	076	056	097
/	/	/	/	/
114	023	041	116	083
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090	065	063	039	120
/	/	/	/	/
021	117	020	084	006
/	/	/	/	/
015	095	018	082	028
115	079	035	001	- - - 002
/	/	/	/	/
099	059	004	096	- - 119
/	/	/	/	/
122	074	068	046	- - 067
/	/	/	/	/
034	-107	-091	-047	098
/	/	/	/	/
104	058	053	050	088
062	078	072	105	- - - 060
/	/	/	/	/
017	036	118	038	- - 024
/	/	/	/	/
080	044	069	026	- - 055
/	/	/	/	/
112	-123	-110	-121	009
/	/	/	/	/
106	092	008	087	089
032	-101	-100	057	- - - 037
/	/	/	/	/
061	108	027	073	- - 005
/	/	/	/	/
124	109	022	051	- - 071
/	/	/	/	/
052	-011	-054	-014	075
/	/	/	/	/
049	048	007	016	010
125	042	094	003	- - - 113
/	/	/	/	/
086	040	045	081	- - 013
/	/	/	/	/
033	085	070	012	- - 093
/	/	/	/	/
030	-019	-102	-111	025
/	/	/	/	/
103	029	066	064	031

Nilai Akhir
Objective
Function

37

Plot



Durasi	24.52 detik
Banyak Restart	2

Banyak Iterasi per Restart	35, 31
Parameter Maksimum Restart	2

Percobaan 3

State Awal	
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State Akhir

026	078	119	046	094
/	/	/	/	/
030	037	070	043	001
/	/	/	/	/
036	081	061	093	092
/	/	/	/	/
091	106	103	123	060
/	/	/	/	/
059	076	010	102	116
/	/	/	/	/
011	002	049	050	- - - 047
/	/	/	/	/
111	067	097	022	- - - 066
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014	017	003	054	- - - 099
/	/	/	/	/
004	085	096	056	122
/	/	/	/	/
007	120	118	005	038
/	/	/	/	/
035	087	068	069	- - - 039
/	/	/	/	/
045	107	052	034	- - - 019
/	/	/	/	/
006	077	074	072	- - - 028
/	/	/	/	/
115	079	021	104	044
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098	013	020	084	109
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048	088	099	018	- - - 110
/	/	/	/	/
053	101	031	008	- - - 024
/	/	/	/	/
086	032	125	062	- - - 058
/	/	/	/	/
112	065	009	023	100
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055	114	080	089	025
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063	016	029	071	- - - 073
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124	051	113	012	- - - 015
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027	042	117	082	- - - 095
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041	121	040	057	105
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108	033	064	083	075

Nilai Akhir Objective Function = 42

Nilai Akhir
Objective
Function

42

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"> <thead> <tr> <th>Jumlah Iterasi</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>1</td><td>3</td></tr> <tr><td>2</td><td>5</td></tr> <tr><td>3</td><td>6</td></tr> <tr><td>4</td><td>7</td></tr> <tr><td>5</td><td>8</td></tr> <tr><td>6</td><td>9</td></tr> <tr><td>7</td><td>10</td></tr> <tr><td>8</td><td>11</td></tr> <tr><td>9</td><td>12</td></tr> <tr><td>10</td><td>14</td></tr> <tr><td>11</td><td>15</td></tr> <tr><td>12</td><td>16</td></tr> <tr><td>13</td><td>17</td></tr> <tr><td>14</td><td>18</td></tr> <tr><td>15</td><td>19</td></tr> <tr><td>16</td><td>20</td></tr> <tr><td>17</td><td>21</td></tr> <tr><td>18</td><td>22</td></tr> <tr><td>19</td><td>23</td></tr> <tr><td>20</td><td>24</td></tr> <tr><td>21</td><td>25</td></tr> <tr><td>22</td><td>26</td></tr> <tr><td>23</td><td>27</td></tr> <tr><td>24</td><td>28</td></tr> <tr><td>25</td><td>29</td></tr> <tr><td>26</td><td>30</td></tr> <tr><td>27</td><td>31</td></tr> <tr><td>28</td><td>32</td></tr> <tr><td>29</td><td>33</td></tr> <tr><td>30</td><td>34</td></tr> <tr><td>31</td><td>35</td></tr> <tr><td>32</td><td>36</td></tr> <tr><td>33</td><td>37</td></tr> <tr><td>34</td><td>38</td></tr> <tr><td>35</td><td>39</td></tr> <tr><td>36</td><td>40</td></tr> <tr><td>37</td><td>41</td></tr> </tbody> </table>	Jumlah Iterasi	Value	1	3	2	5	3	6	4	7	5	8	6	9	7	10	8	11	9	12	10	14	11	15	12	16	13	17	14	18	15	19	16	20	17	21	18	22	19	23	20	24	21	25	22	26	23	27	24	28	25	29	26	30	27	31	28	32	29	33	30	34	31	35	32	36	33	37	34	38	35	39	36	40	37	41
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Durasi	15.044 detik																																																																												
Banyak Restart	1																																																																												
Banyak Iterasi per Restart	38																																																																												
Parameter Maksimum Restart	1																																																																												

- Hill Climb : Stochastic

Percobaan 1

State Awa

070	114	054	-104	036
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022	052	051	012	092
/	/	/	/	/
038	096	113	099	043
/	/	/	/	/
094	-090	-121	-107	-009
/	/	/	/	/
118	008	-013	087	108
078	-003	-071	-069	-109
/	/	/	/	/
082	-117	-081	-063	-111
/	/	/	/	/
002	-098	-010	-029	-016
/	/	/	/	/
119	-100	-018	-084	015
/	/	/	/	/
058	-105	-021	-047	050
039	-048	-075	-024	-120
/	/	/	/	/
017	-059	-027	-080	-037
/	/	/	/	/
057	-116	-083	-023	-106
/	/	/	/	/
045	-074	-011	-110	042
/	/	/	/	/
030	-125	-091	-005	101
044	-067	-112	-072	-1049
/	/	/	/	/
060	-089	-068	-053	-065
/	/	/	/	/
033	-055	-097	-006	-093
/	/	/	/	/
056	-122	-073	-115	123
/	/	/	/	/
040	-102	-019	-076	103
095	-064	-041	-032	-1085
/	/	/	/	/
028	-066	-079	-025	-1014
/	/	/	/	/
124	-001	-020	-007	-077
/	/	/	/	/
061	-004	-035	-031	034
/	/	/	/	/
086	-062	-026	-088	-046

State Akhir

070	114	054	104	036
/	/	/	/	/
022	052	051	012	092
/	/	/	/	/
038	096	113	099	043
/	/	/	/	/
094	090	121	107	009
/	/	/	/	/
118	008	013	087	108
078	003	071	069	- - -109
/	/	/	/	/
082	117	081	063	- - 111
/	/	/	/	/
002	098	035	029	- 016
/	/	/	/	/
119	-100	-018	-084	015
/	/	/	/	/
058	057	021	047	050
039	048	075	024	- - -120
/	/	/	/	/
017	059	027	080	- - 037
/	/	/	/	/
105	116	083	023	- 106
/	/	/	/	/
045	-074	-011	-110	042
/	/	/	/	/
030	125	091	005	101
044	067	112	072	- - -049
/	/	/	/	/
060	089	068	053	- - 065
/	/	/	/	/
033	055	097	006	- 093
/	/	/	/	/
056	-122	-073	-115	123
/	/	/	/	/
040	102	019	076	103
095	064	041	032	- - -085
/	/	/	/	/
028	066	079	025	- - 014
/	/	/	/	/
124	001	020	007	- 077
/	/	/	/	/
061	-004	-010	-031	034
/	/	/	/	/
086	062	026	088	046

Nilai Akhir
Objective
Function

5

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"><thead><tr><th>Jumlah Iterasi</th><th>Value</th></tr></thead><tbody><tr><td>0</td><td>3.00</td></tr><tr><td>5</td><td>4.00</td></tr><tr><td>50</td><td>5.00</td></tr><tr><td>100</td><td>5.00</td></tr></tbody></table>	Jumlah Iterasi	Value	0	3.00	5	4.00	50	5.00	100	5.00
Jumlah Iterasi	Value										
0	3.00										
5	4.00										
50	5.00										
100	5.00										
Durasi	0.002 detik										
Banyak Iterasi	100										

Percobaan 2

State Awal

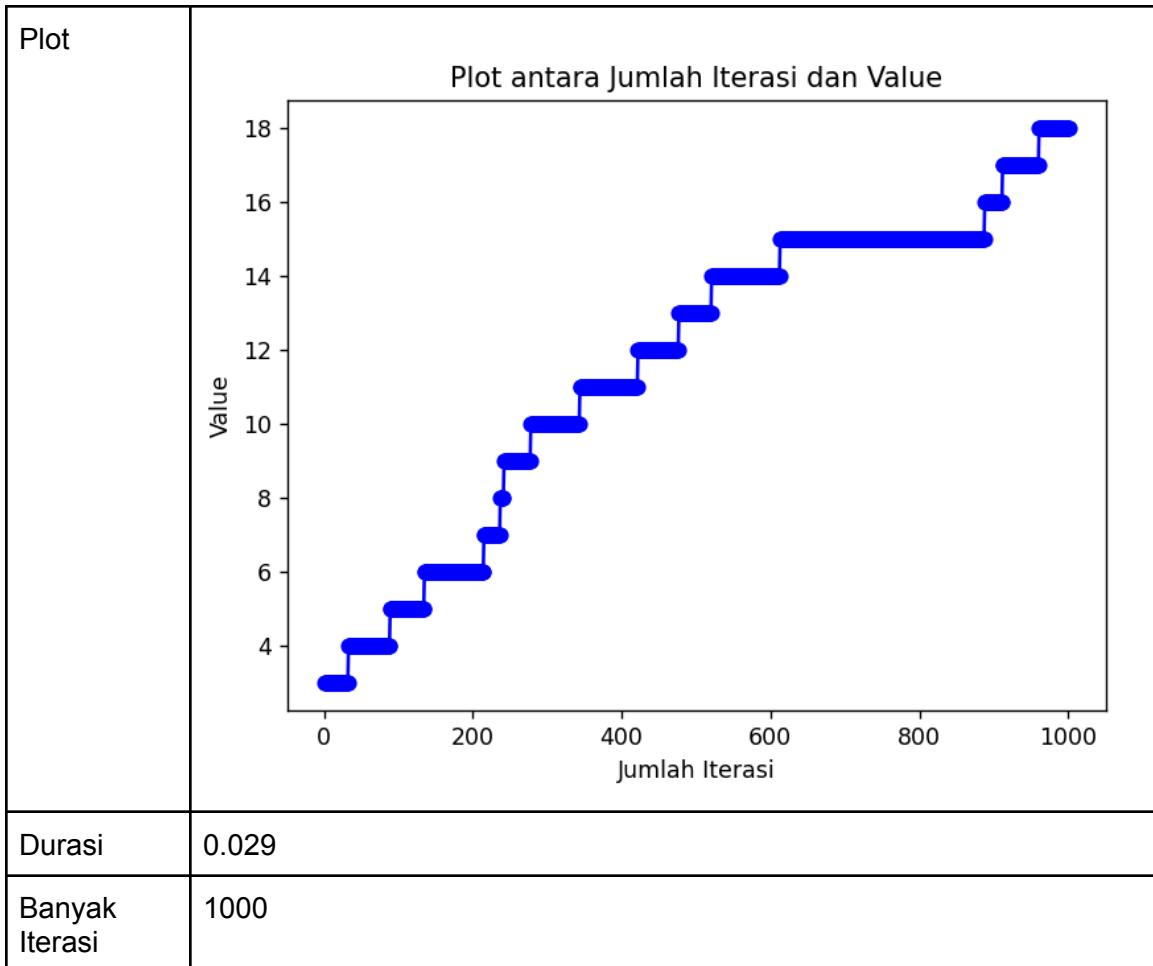
085	074	037	117	021
/	/	/	/	/
109	032	062	072	094
/	/	/	/	/
025	099	086	122	108
/	/	/	/	/
091	083	005	058	064
/	/	/	/	/
081	017	103	093	067
123	009	008	071	- - - 059
/	/	/	/	/
018	113	075	055	- - 052
/	/	/	/	/
006	050	090	015	- 042
/	/	/	/	/
084	014	104	107	007
/	/	/	/	/
114	087	056	013	001
101	003	029	110	- - - 051
/	/	/	/	/
061	116	097	079	- - 040
/	/	/	/	/
120	115	118	049	- 100
/	/	/	/	/
016	026	053	057	073
/	/	/	/	/
044	022	033	027	043
125	028	124	035	- - - 096
/	/	/	/	/
063	004	121	020	- - 047
/	/	/	/	/
060	068	054	041	- 065
/	/	/	/	/
106	092	069	023	024
/	/	/	/	/
070	112	019	046	111
011	095	034	102	- - - 031
/	/	/	/	/
082	012	088	089	- - 038
/	/	/	/	/
048	045	078	098	- 002
/	/	/	/	/
066	030	105	119	036
/	/	/	/	/
076	010	039	080	077

State Akhir

085	074	037	117	123
/	/	/	/	/
048	032	062	022	094
/	/	/	/	/
025	038	086	122	108
/	/	/	/	/
091	083	005	089	064
/	/	/	/	/
081	017	103	093	067
021	009	008	071	- - -059
/	/	/	/	/ /
018	113	075	055	- - 052
/	/	/	/	/ /
041	050	090	015	- 042
/	/	/	/	/ /
084	-014	-120	-107	007
/	/	/	/	/
114	006	056	013	001
101	003	029	110	- - -051
/	/	/	/	/ /
061	116	097	079	- - 040
/	/	/	/	/ /
104	115	118	010	- 100
/	/	/	/	/ /
016	-026	-033	-057	073
/	/	/	/	/
044	072	053	076	068
049	028	124	035	- - -096
/	/	/	/	/ /
063	004	121	020	- - 047
/	/	/	/	/ /
060	043	054	087	- 065
/	/	/	/	/ /
106	-092	-069	-023	024
/	/	/	/	/
070	112	019	046	111
027	119	034	102	- - -031
/	/	/	/	/ /
082	012	088	058	- - 099
/	/	/	/	/ /
109	045	078	098	- 002
/	/	/	/	/
066	-030	-105	-095	036
/	/	/	/	/
011	125	039	080	077

Nilai Akhir
Objective
Function

18



Percobaan 3

State Awal

024	068	-045	008	086
/	/	/	/	/
066	020	063	060	050
/	/	/	/	/
057	042	071	118	037
/	/	/	/	/
108	115	011	-117	087
/	/	/	/	/
079	073	059	119	078
094	122	111	091	- - -097
/	/	/	/	/
019	039	054	012	- - -029
/	/	/	/	/
082	109	112	075	- - -076
/	/	/	/	/
092	031	099	041	035
/	/	/	/	/
023	121	003	124	010
096	077	114	044	- - -105
/	/	/	/	/
021	106	014	033	- - -036
/	/	/	/	/
006	069	098	083	- - -093
/	/	/	/	/
090	051	025	-125	064
/	/	/	/	/
043	123	116	084	101
028	113	040	056	- - -081
/	/	/	/	/
103	070	004	100	- - -013
/	/	/	/	/
027	015	001	049	- - -053
/	/	/	/	/
038	030	-080	-055	104
/	/	/	/	/
120	088	032	005	107
034	061	022	018	- - -026
/	/	/	/	/
072	062	085	095	- - -102
/	/	/	/	/
046	007	110	002	- - -067
/	/	/	/	/
089	-017	016	-058	074
/	/	/	/	/
052	047	048	065	009

State Akhir

024	068	045	008	086
/	/	/	/	/
066	020	063	060	050
/	/	/	/	/
104	042	071	118	037
/	/	/	/	/
108	115	011	117	087
/	/	/	/	/
076	073	059	119	049
/	/	/	/	/
094	122	111	091	- - - 097
/	/	/	/	/
019	039	054	012	- - - 029
/	/	/	/	/
082	109	112	075	- - - 079
/	/	/	/	/
092	031	099	041	035
/	/	/	/	/
023	121	003	124	010
/	/	/	/	/
096	077	114	044	- - - 105
/	/	/	/	/
021	106	014	033	- - - 036
/	/	/	/	/
006	069	098	083	- - - 093
/	/	/	/	/
090	051	015	125	064
/	/	/	/	/
043	123	116	084	101
/	/	/	/	/
028	113	040	056	- - - 081
/	/	/	/	/
103	061	004	100	- - - 013
/	/	/	/	/
027	025	001	065	- - - 002
/	/	/	/	/
038	030	080	055	078
/	/	/	/	/
120	088	032	005	107
/	/	/	/	/
034	067	022	018	- - - 026
/	/	/	/	/
072	062	085	095	- - - 102
/	/	/	/	/
046	007	110	053	- - - 070
/	/	/	/	/
089	017	016	058	074
/	/	/	/	/
052	047	048	057	009

Nilai Akhir Objective Function = 12

**Nilai Akhir
Objective
Function**

12

Plot	<p style="text-align: center;">Plot antara Jumlah Iterasi dan Value</p> <table border="1"> <thead> <tr> <th>Jumlah Iterasi</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>0</td><td>3</td></tr> <tr><td>0</td><td>4</td></tr> <tr><td>130</td><td>6</td></tr> <tr><td>230</td><td>8</td></tr> <tr><td>340</td><td>10</td></tr> <tr><td>380</td><td>12</td></tr> </tbody> </table>	Jumlah Iterasi	Value	0	3	0	4	130	6	230	8	340	10	380	12
Jumlah Iterasi	Value														
0	3														
0	4														
130	6														
230	8														
340	10														
380	12														
Durasi	0.014 detik														
Banyak Iterasi	500														

- Simulated Annealing

Percobaan 1

State Awal :

117	-097	-035	-072	-013
/	/	/	/	/
055	-082	-022	-032	-036
/	/	/	/	/
107	-061	-034	-110	-033
/	/	/	/	/
064	-018	-027	-121	-112
/	/	/	/	/
085	-095	-058	-083	-019
001	-021	-089	-100	-030
/	/	/	/	/
025	-116	-106	-041	-123
/	/	/	/	/
005	-004	-077	-118	-057
/	/	/	/	/
074	-119	-073	-080	-039
/	/	/	/	/
115	-049	-105	-050	-109
066	-067	-079	-054	-070
/	/	/	/	/
102	-068	-104	-086	-040
/	/	/	/	/
076	-088	-024	-020	-081
/	/	/	/	/
008	-087	-017	-043	-056
/	/	/	/	/
002	-069	-065	-012	-091
114	-075	-094	-023	-010
/	/	/	/	/
047	-031	-016	-090	-007
/	/	/	/	/
060	-113	-053	-029	-003
/	/	/	/	/
037	-009	-048	-059	-015
/	/	/	/	/
103	-006	-108	-125	-098
026	-084	-078	-051	-063
/	/	/	/	/
052	-124	-111	-046	-045
/	/	/	/	/
028	-042	-101	-038	-122
/	/	/	/	/
014	-011	-120	-099	-044
/	/	/	/	/
096	-071	-093	-062	-092

States : 115

State Akhir :

102	-084	-050	-023	-103
/	/	/	/	/
011	-006	-079	-101	-098
/	/	/	/	/
067	-047	-034	-118	-096
/	/	/	/	/
083	-024	-076	-039	-122
/	/	/	/	/
093	-072	-085	-033	-019
/	/	/	/	/
022	-012	-121	-036	-074
/	/	/	/	/
028	-113	-053	-063	-105
/	/	/	/	/
082	-014	-081	-061	-029
/	/	/	/	/
088	-109	-004	-059	-071
/	/	/	/	/
010	-086	-003	-016	-114
/	/	/	/	/
110	-091	-042	-025	-007
/	/	/	/	/
041	-045	-040	-125	-073
/	/	/	/	/
107	-116	-037	-044	-058
/	/	/	/	/
095	-054	-120	-078	-097
/	/	/	/	/
027	-065	-123	-021	-001
/	/	/	/	/
080	-124	-112	-115	-015
/	/	/	/	/
017	-090	-070	-020	-068
/	/	/	/	/
052	-099	-087	-094	-069
/	/	/	/	/
066	-117	-106	-018	-055
/	/	/	/	/
038	-104	-043	-026	-002
/	/	/	/	/
057	-051	-008	-064	-077
/	/	/	/	/
048	-108	-111	-046	-049
/	/	/	/	/
089	-119	-005	-062	-060
/	/	/	/	/
030	-009	-056	-031	-032
/	/	/	/	/
100	-035	-075	-013	-092

Nilai Akhir
Objective
Function

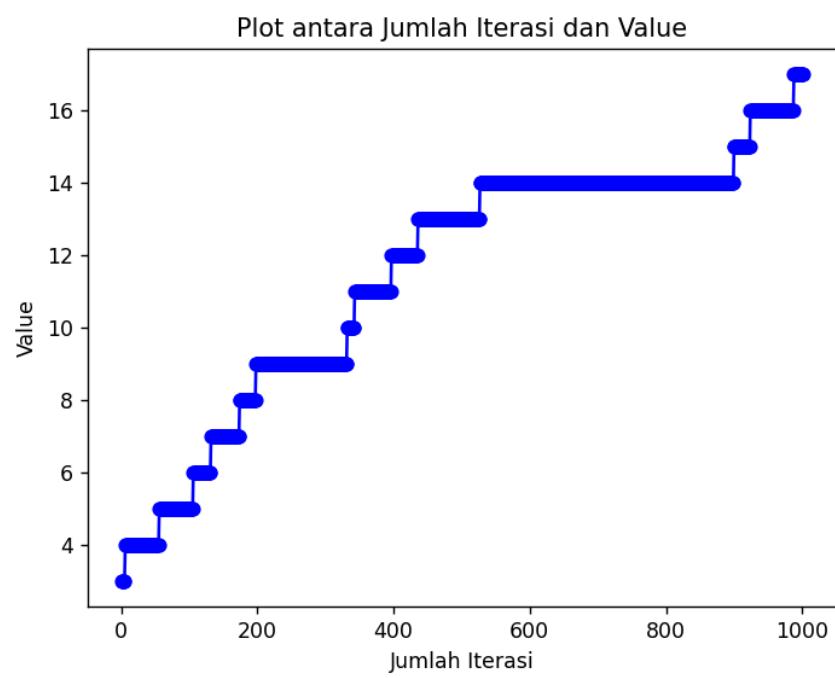
17

Durasi 0.051 detik

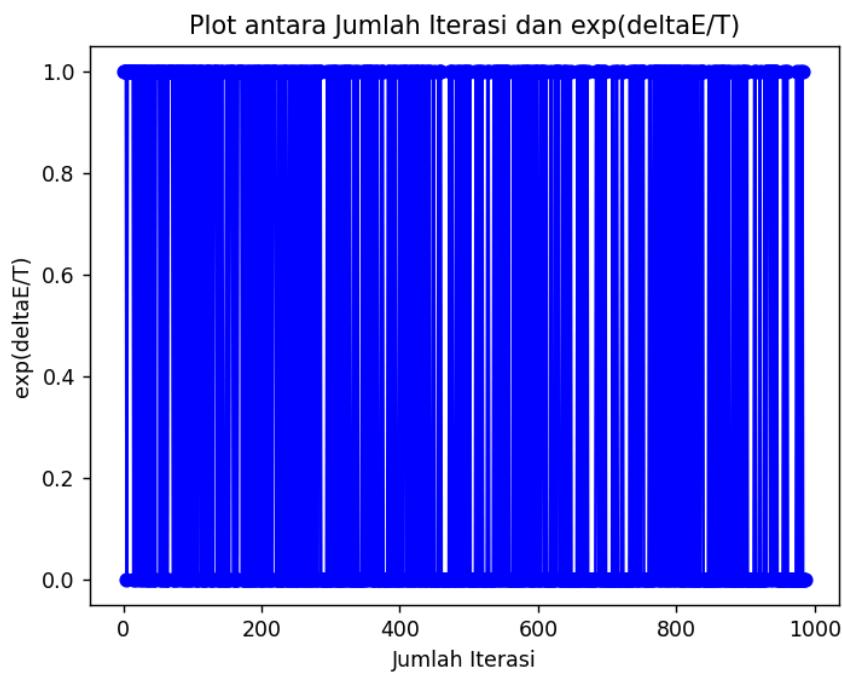
Frekuensi
stuck di
lokal
optima

986

Plot
(objective
function)



Plot
 $\frac{\Delta E}{T}$
($e^{-\frac{\Delta E}{T}}$)



Percobaan 2

State Awal :

004	-----	055	-----	111	-----	072	-----	070
/		/		/		/		/
033	-----	079	-----	030	-----	029	-----	038
/		/		/		/		/
020	-----	117	-----	031	-----	056	-----	014
/		/		/		/		/
023	-----	093	-----	019	-----	048	-----	065
/		/		/		/		/
049	-----	099	-----	017	-----	122	-----	102
008	-----	118	-----	046	-----	089	-----	125
/		/		/		/		/
054	-----	116	-----	110	-----	069	-----	084
/		/		/		/		/
021	-----	053	-----	002	-----	058	-----	024
/		/		/		/		/
048	-----	003	-----	039	-----	043	-----	062
/		/		/		/		/
028	-----	076	-----	022	-----	124	-----	064
092	-----	067	-----	075	-----	061	-----	083
/		/		/		/		/
086	-----	120	-----	085	-----	032	-----	074
/		/		/		/		/
013	-----	073	-----	011	-----	101	-----	041
/		/		/		/		/
016	-----	006	-----	114	-----	009	-----	034
/		/		/		/		/
057	-----	082	-----	096	-----	027	-----	026
091	-----	071	-----	050	-----	078	-----	077
/		/		/		/		/
105	-----	052	-----	080	-----	108	-----	097
/		/		/		/		/
068	-----	119	-----	035	-----	051	-----	059
/		/		/		/		/
045	-----	066	-----	100	-----	095	-----	113
/		/		/		/		/
036	-----	115	-----	007	-----	123	-----	047
103	-----	037	-----	088	-----	107	-----	018
/		/		/		/		/
112	-----	094	-----	109	-----	087	-----	104
/		/		/		/		/
042	-----	081	-----	012	-----	025	-----	001
/		/		/		/		/
005	-----	090	-----	063	-----	098	-----	010
/		/		/		/		/
121	-----	106	-----	060	-----	015	-----	044

State Akhir :

112-----	094-----	063-----	069-----	001-----
/ -----	/ -----	/ -----	/ -----	/ -----
075-----	-013-----	107-----	040-----	-104-----
/ -----	/ -----	/ -----	/ -----	/ -----
005-----	-068-----	-110-----	123-----	-074-----
/ -----	/ -----	/ -----	/ -----	/ -----
033-----	-017-----	-119-----	024-----	-034-----
/ -----	/ -----	/ -----	/ -----	/ -----
084-----	-049-----	079-----	027-----	-003-----
-----	-----	-----	-----	-----
073-----	-014-----	045-----	083-----	-035-----
/ -----	/ -----	/ -----	/ -----	/ -----
062-----	-048-----	030-----	100-----	-099-----
/ -----	/ -----	/ -----	/ -----	/ -----
046-----	-125-----	-067-----	089-----	-023-----
/ -----	/ -----	/ -----	/ -----	/ -----
070-----	-105-----	-020-----	-108-----	-009-----
/ -----	/ -----	/ -----	/ -----	/ -----
032-----	-022-----	012-----	071-----	-015-----
-----	-----	-----	-----	-----
078-----	-087-----	085-----	025-----	-041-----
/ -----	/ -----	/ -----	/ -----	/ -----
095-----	-004-----	054-----	066-----	-120-----
/ -----	/ -----	/ -----	/ -----	/ -----
019-----	-006-----	-061-----	113-----	-122-----
/ -----	/ -----	/ -----	/ -----	/ -----
042-----	-047-----	-102-----	-103-----	-114-----
/ -----	/ -----	/ -----	/ -----	/ -----
088-----	-026-----	096-----	072-----	-057-----
-----	-----	-----	-----	-----
064-----	-086-----	010-----	116-----	-050-----
/ -----	/ -----	/ -----	/ -----	/ -----
055-----	-097-----	043-----	011-----	-036-----
/ -----	/ -----	/ -----	/ -----	/ -----
053-----	-059-----	-029-----	109-----	-037-----
/ -----	/ -----	/ -----	/ -----	/ -----
060-----	-115-----	-090-----	091-----	-031-----
/ -----	/ -----	/ -----	/ -----	/ -----
081-----	-077-----	101-----	093-----	-058-----
-----	-----	-----	-----	-----
111-----	-082-----	008-----	080-----	-121-----
/ -----	/ -----	/ -----	/ -----	/ -----
028-----	-002-----	098-----	065-----	-018-----
/ -----	/ -----	/ -----	/ -----	/ -----
056-----	-052-----	-106-----	-124-----	-039-----
/ -----	/ -----	/ -----	/ -----	/ -----
021-----	-007-----	-118-----	-076-----	-117-----
/ -----	/ -----	/ -----	/ -----	/ -----
092-----	-016-----	051-----	038-----	-044-----
-----	-----	-----	-----	-----

Nilai Akhir
Objective
Function

18

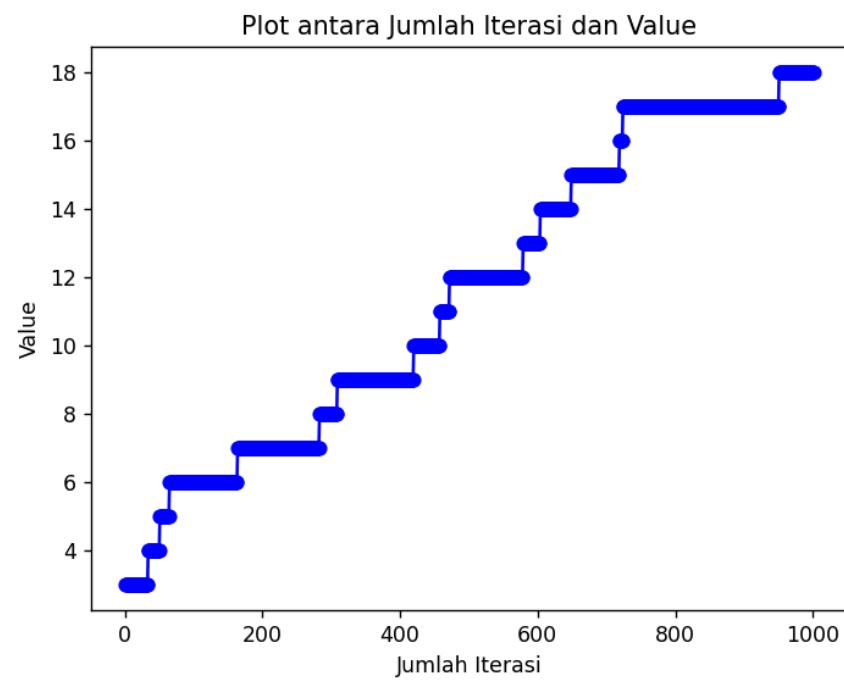
Durasi

0.052 detik

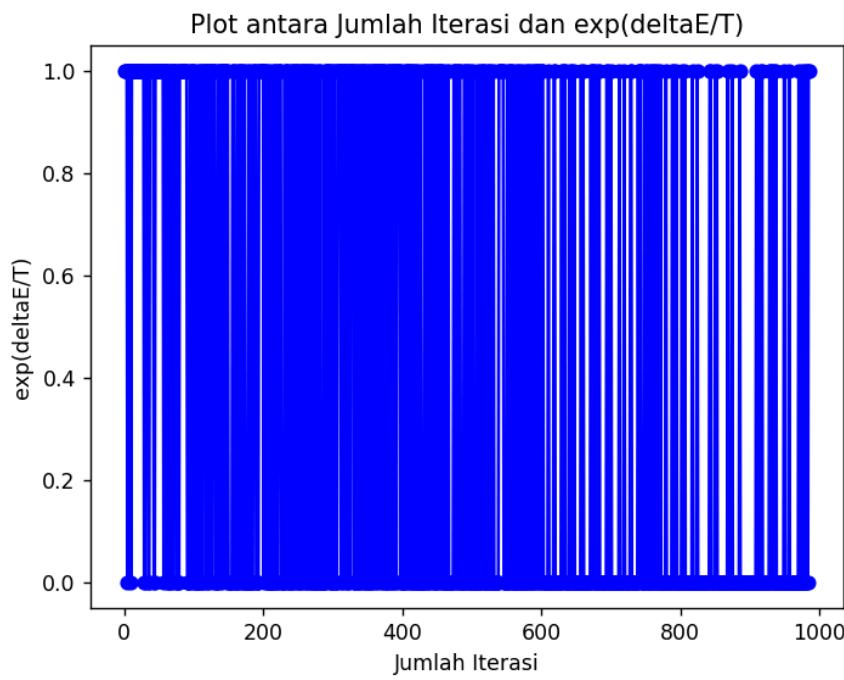
Frekuensi
stuck di
lokal
optima

985

Plot
(objective
function)



Plot
 $\frac{\Delta E}{T}$
($e^{-\frac{\Delta E}{T}}$)

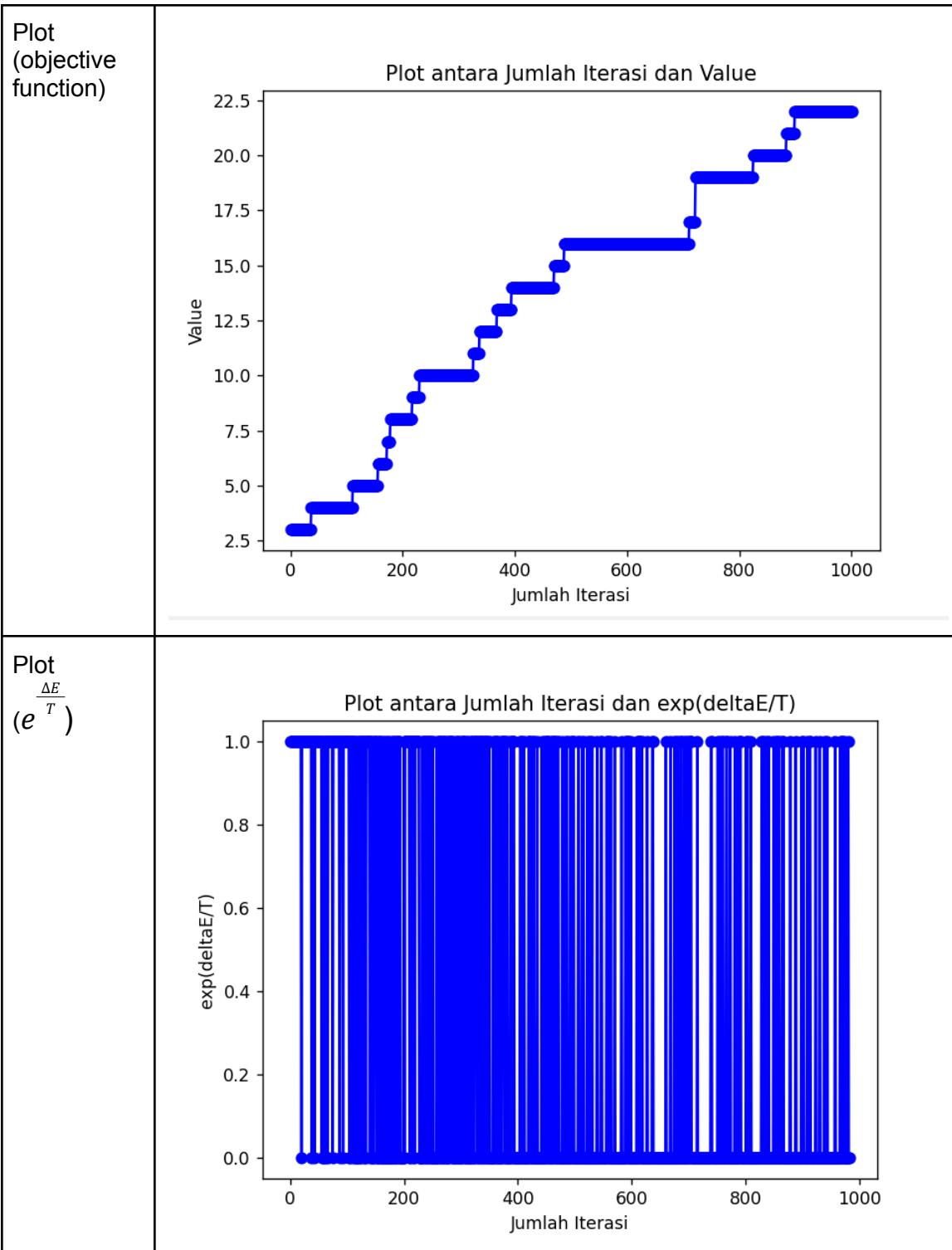


Percobaan 3

State Awal

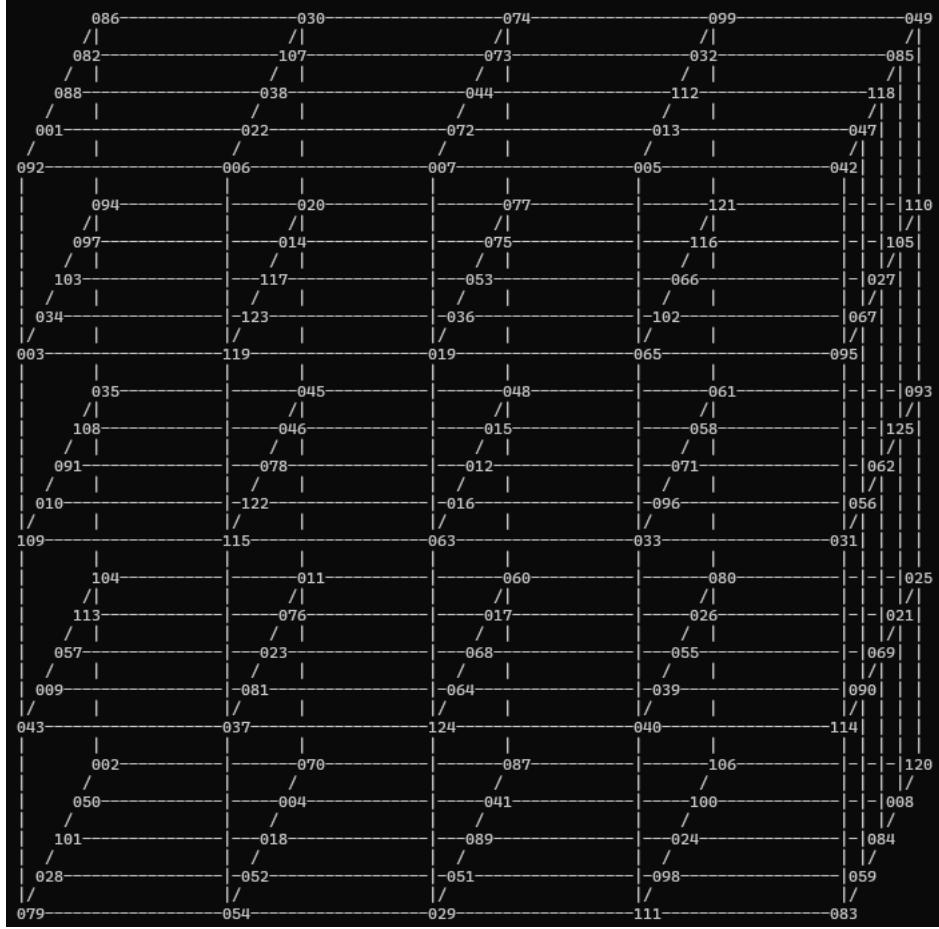
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064-	-072-	-075-	-083-	-115
/	/	/	/	/
058-	-110-	-124-	-029-	-093
/	/	/	/	/
076-	-025-	-106-	-098-	-096
/	/	/	/	/
032-	-024-	-055-	-054-	-087
117-	-017-	-120-	-053-	- - -095
/	/	/	/	/
046-	-039-	-027-	-052-	- - -003
/	/	/	/	/
008-	-011-	-077-	-050-	- - -097
/	/	/	/	/
089-	-074-	-028-	-026-	- - -019
/	/	/	/	/
021-	-018-	-004-	-078-	-107
036-	-001-	-023-	-062-	- - -085
/	/	/	/	/
006-	-012-	-108-	-037-	- - -016
/	/	/	/	/
041-	-102-	-071-	-013-	- - -122
/	/	/	/	/
084-	-040-	-119-	-061-	- - -002
/	/	/	/	/
113-	-038-	-105-	-063-	-042
091-	-056-	-118-	-009-	- - -049
/	/	/	/	/
051-	-035-	-065-	-060-	- - -094
/	/	/	/	/
069-	-109-	-092-	-047-	- - -067
/	/	/	/	/
101-	-121-	-034-	-043-	- - -068
/	/	/	/	/
073-	-088-	-090-	-099-	- - -070
079-	-020-	-081-	-112-	- - -014
/	/	/	/	/
100-	-066-	-103-	-080-	- - -030
/	/	/	/	/
111-	-086-	-048-	-082-	- - -010
/	/	/	/	/
116-	-059-	-123-	-015-	- - -045
/	/	/	/	/
114-	-104-	-057-	-044-	- - -007

State Akhir	084-----068-----083-----090-----071 / / / / / 034-----059-----002-----013-----118 / / / / / 098-----019-----031-----086-----001 / / / / / 073-----051-----096-----036-----077 / / / / / 080-----087-----055-----045-----066 037-----112-----011-----095-----097 / / / / / / / 014-----115-----075-----016-----060 / / / / / / 099-----092-----047-----078-----017 / / / / / / 111-----101-----023-----082-----010 / / / / / / 072-----048-----039-----085-----052 065-----105-----004-----030-----027 / / / / / / 044-----102-----029-----041-----035 / / / / / / 057-----008-----125-----005-----003 / / / / / / 067-----040-----119-----009-----043 / / / / / / 100-----089-----056-----108-----032 050-----093-----025-----091-----074 / / / / / / 015-----061-----123-----038-----006 / / / / / / 021-----022-----064-----076-----116 / / / / / / 049-----033-----018-----104-----122 / / / / / / 028-----124-----103-----107-----054 070-----046-----094-----020-----024 / / / / / / 053-----110-----088-----117-----114 / / / / / / 058-----062-----026-----081-----106 / / / / / / 012-----113-----079-----120-----063 / / / / / / 042-----109-----121-----069-----007
Nilai Akhir Objective Function	22
Durasi	0.05 detik
Frekuensi stuck di lokal optima	982

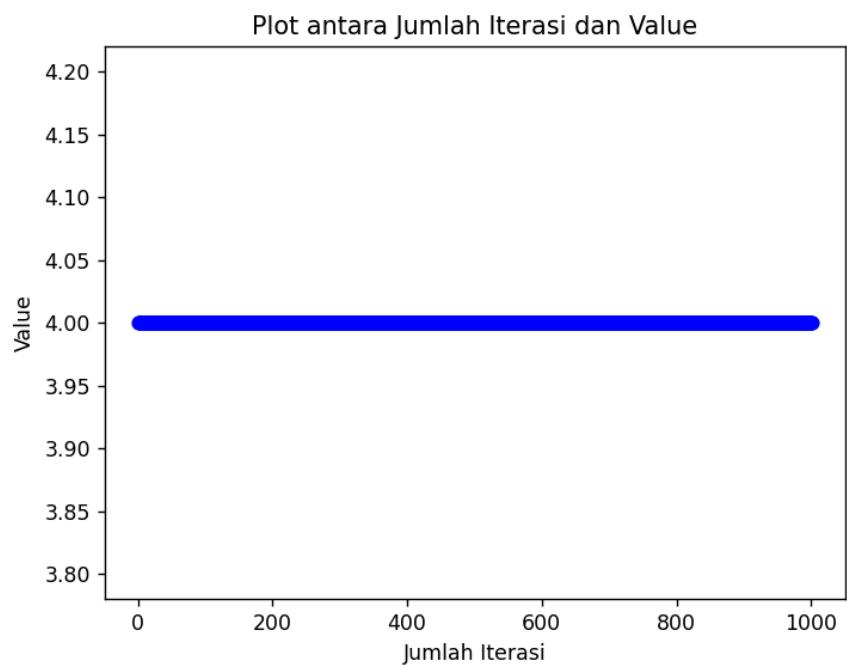


- Genetic Algorithm
 Eksperimen 1-1, populasi sebagai kontrol

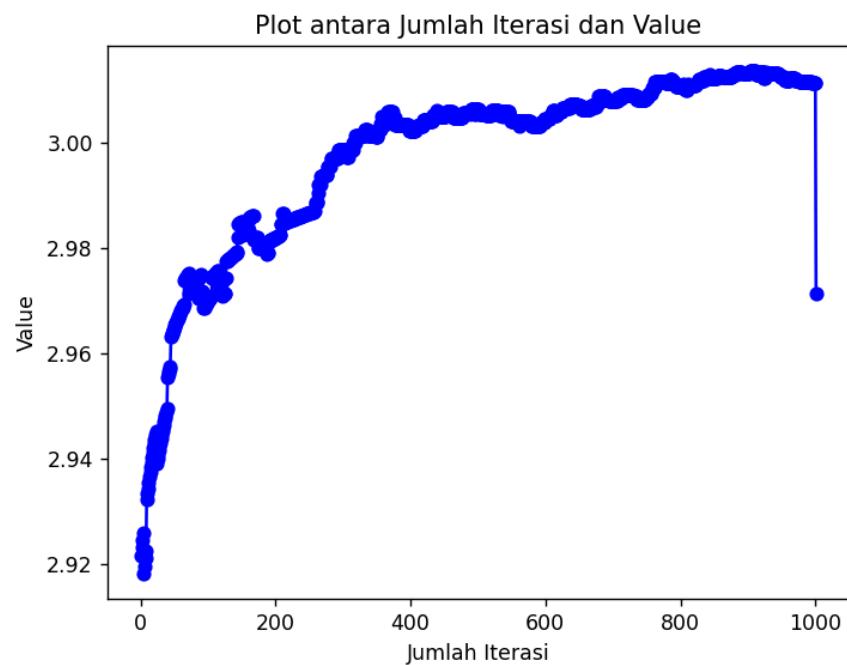
State Awal



State Akhir	<pre> 086-----030-----074-----099-----049 / / / / / 082-----107-----073-----032-----085 / / / / / 088-----038-----044-----112-----118 / / / / / 001-----022-----072-----013-----047 / / / / / 092-----006-----007-----005-----110 094-----020-----077-----121-----042 / / / / / 097-----014-----075-----116-----105 / / / / / 103-----117-----053-----066-----027 / / / / / 034-----123-----036-----102-----067 / / / / / 003-----119-----019-----065-----095 035-----045-----048-----061-----093 / / / / / 108-----046-----015-----058-----125 / / / / / 091-----078-----012-----071-----062 / / / / / 010-----122-----016-----096-----056 / / / / / 109-----115-----063-----033-----031 104-----011-----060-----080-----025 / / / / / 113-----076-----017-----026-----021 / / / / / 057-----023-----068-----055-----069 / / / / / 009-----081-----064-----039-----090 / / / / / 043-----037-----124-----040-----114 002-----070-----087-----106-----120 / / / / / 050-----004-----041-----100-----008 / / / / / 101-----018-----089-----024-----084 / / / / / 028-----052-----051-----098-----059 / / / / / 079-----054-----029-----111-----083 </pre>
Nilai Akhir Objective Function	4
Plot (objective function)	Nilai maksimal



Nilai rata-rata



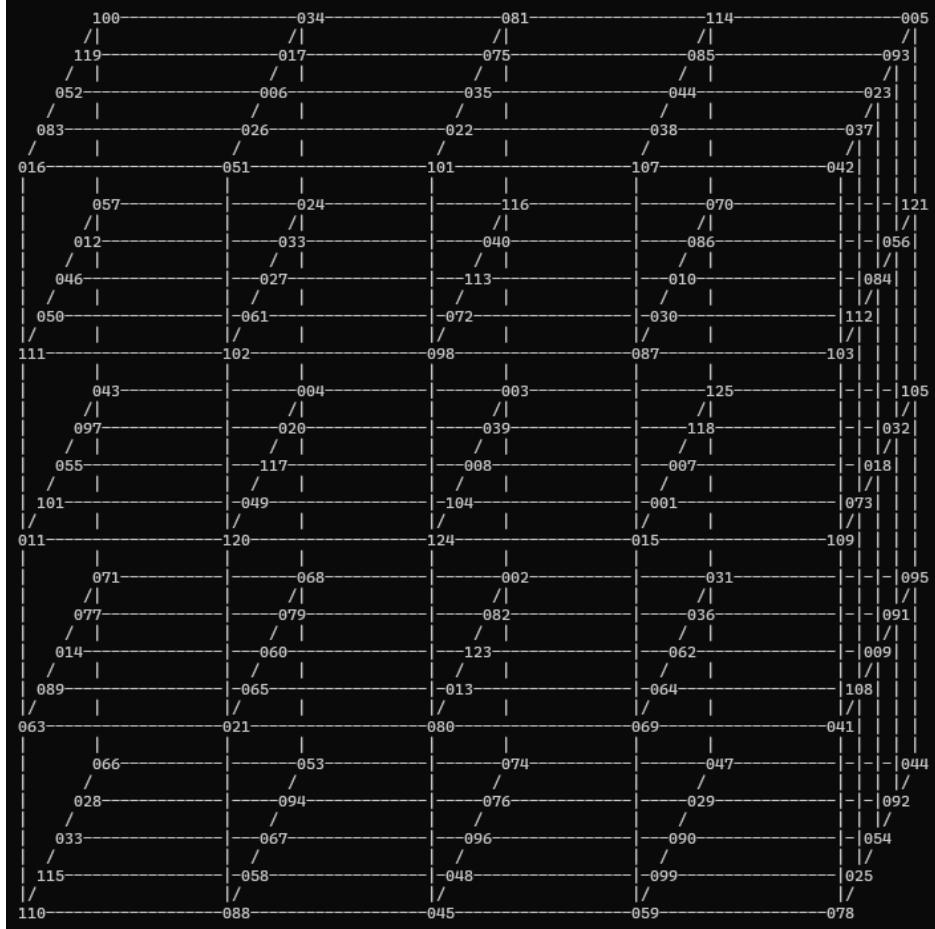
Jumlah populasi	100
Banyak	1000

iterasi	
Durasi	0.206s

Eksperimen 1-2, populasi sebagai kontrol

State Awal	100	034	081	114	005
/	/	/	/	/	/
119	017	075	085	023	093
/	/	/	/	/	/
052	006	035	044	021	
/	/	/	/	/	
083	026	022	038	037	
/	/	/	/	/	
016	051	019	107	042	
/	/	/	/	/	
057	024	116	070	121	
/	/	/	/	/	
012	122	040	086	056	
/	/	/	/	/	
046	027	113	010	084	
/	/	/	/	/	
050	061	072	030	112	
/	/	/	/	/	
111	102	098	087	103	
/	/	/	/	/	
043	004	003	125	105	
/	/	/	/	/	
097	020	039	118	032	
/	/	/	/	/	
055	117	008	007	018	
/	/	/	/	/	
101	049	104	001	073	
/	/	/	/	/	
011	120	124	015	109	
/	/	/	/	/	
071	068	002	031	095	
/	/	/	/	/	
077	079	082	036	091	
/	/	/	/	/	
014	060	123	062	009	
/	/	/	/	/	
089	065	013	064	188	
/	/	/	/	/	
063	021	080	069	041	
/	/	/	/	/	
066	053	074	047	106	
/	/	/	/	/	
028	094	076	029	092	
/	/	/	/	/	
033	067	096	090	054	
/	/	/	/	/	
115	058	048	099	025	
/	/	/	/	/	
110	088	045	059	078	

State Akhir

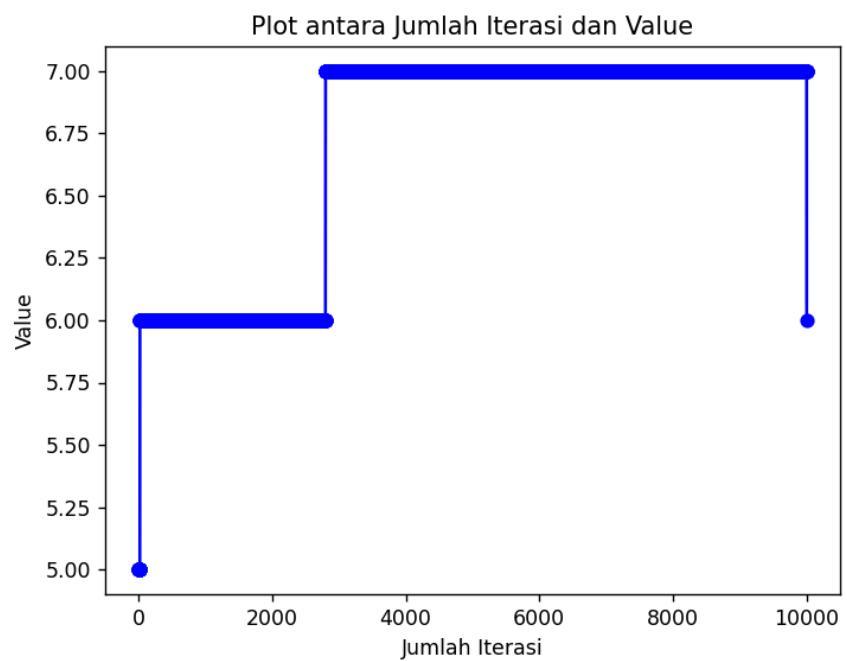


Nilai Akhir
Objective
Function

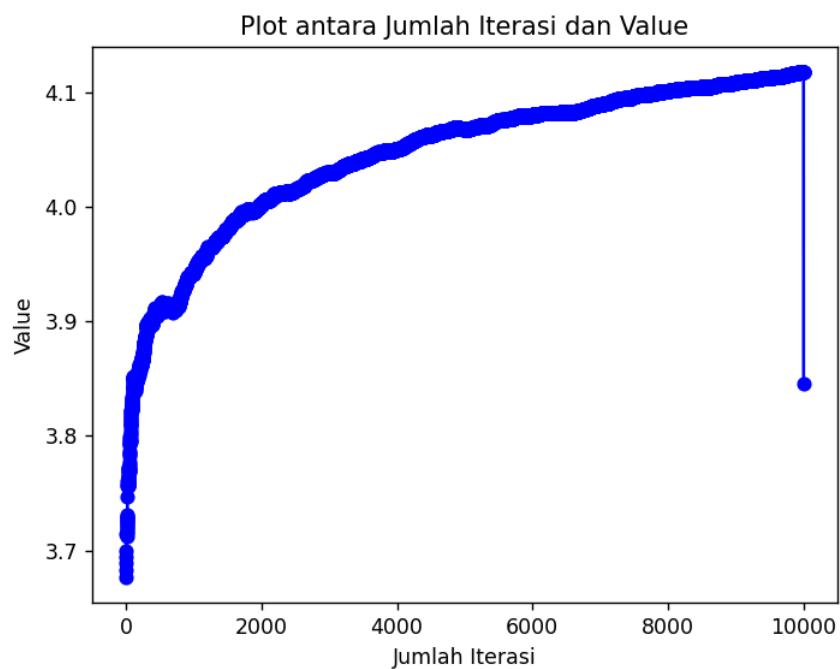
7

Plot
(objective
function)

Nilai maksimal



Nilai rata-rata



Jumlah populasi

100

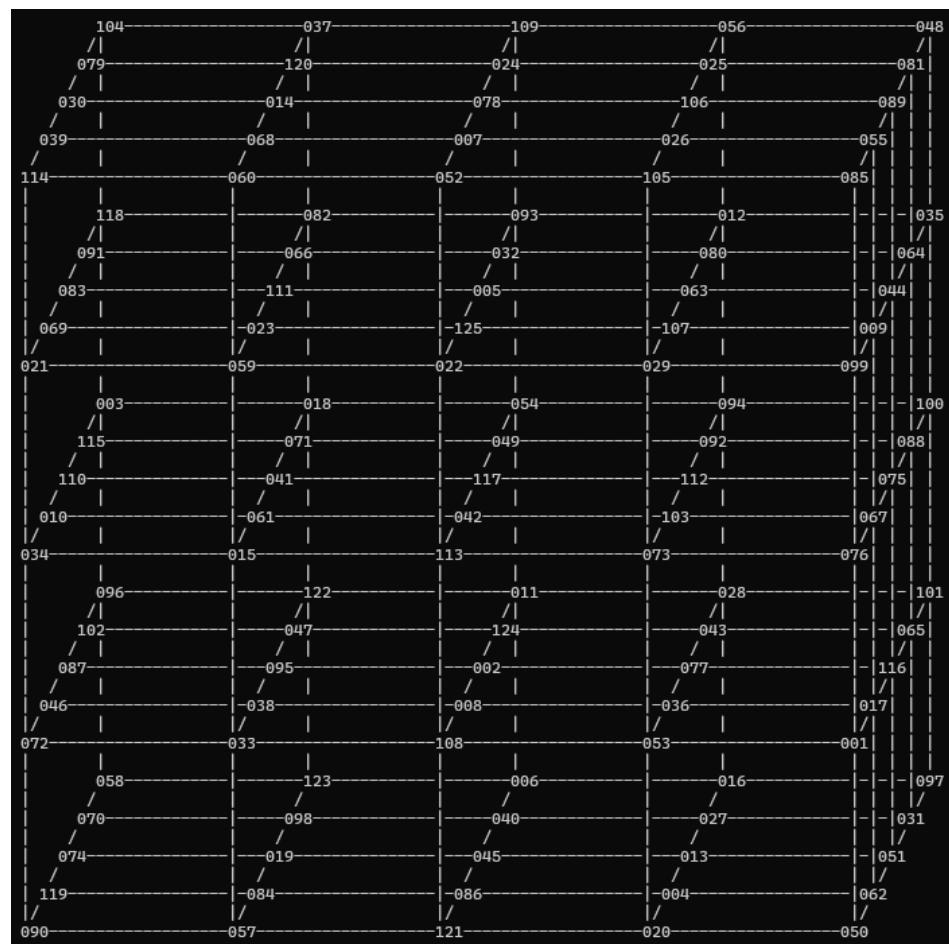
Banyak iterasi

10000

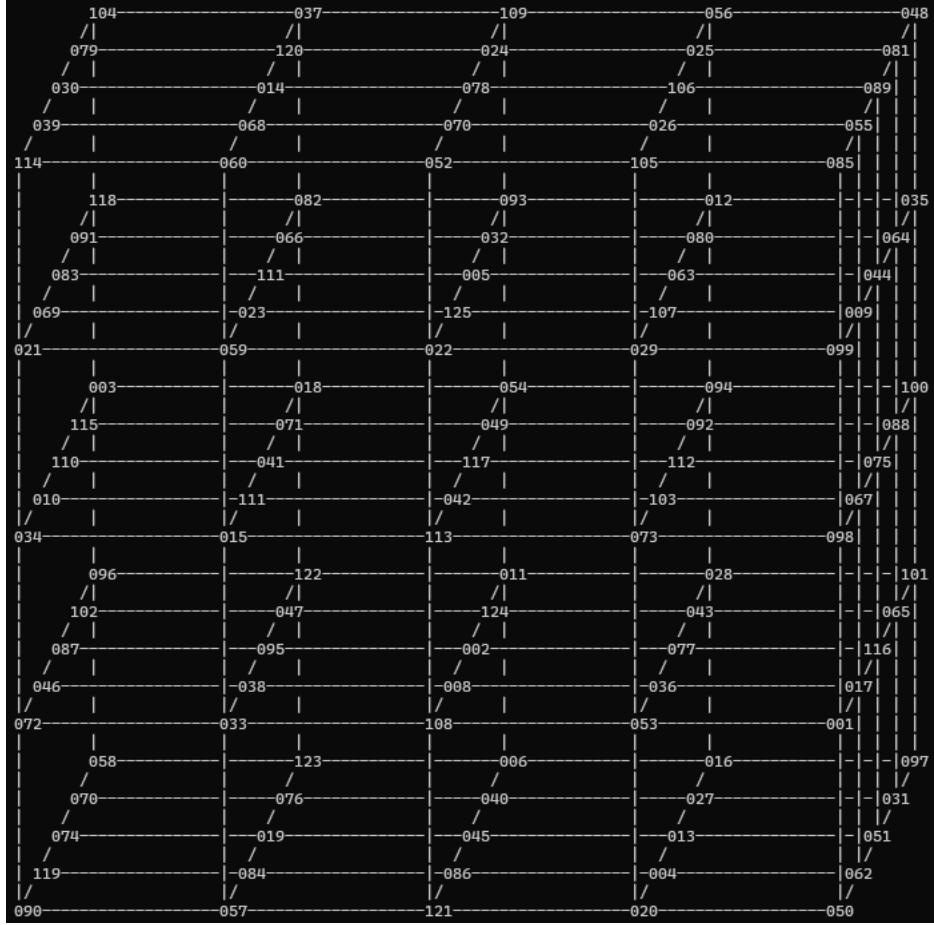
Durasi	4.225s
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Eksperimen 1-3, populasi sebagai kontrol

State Awal



State Akhir

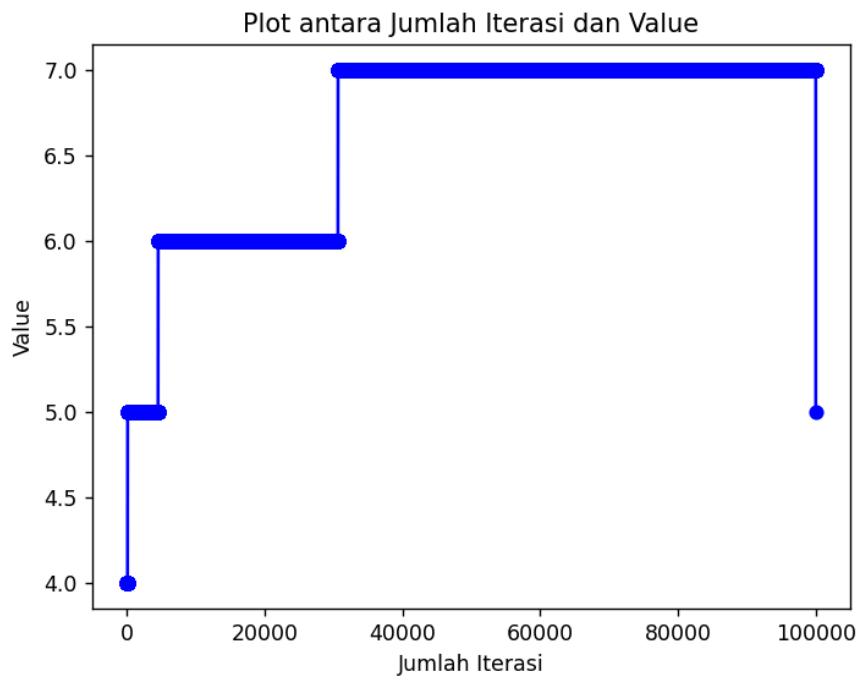


**Nilai Akhir
Objective
Function**

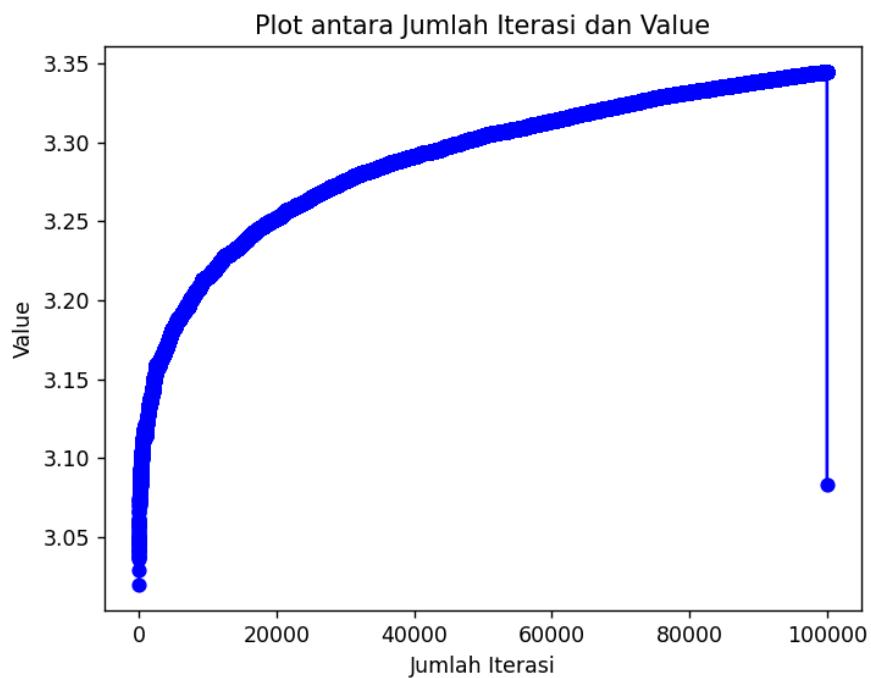
7

**Plot
(objective
function)**

Nilai maksimum:



Nilai rata-rata:

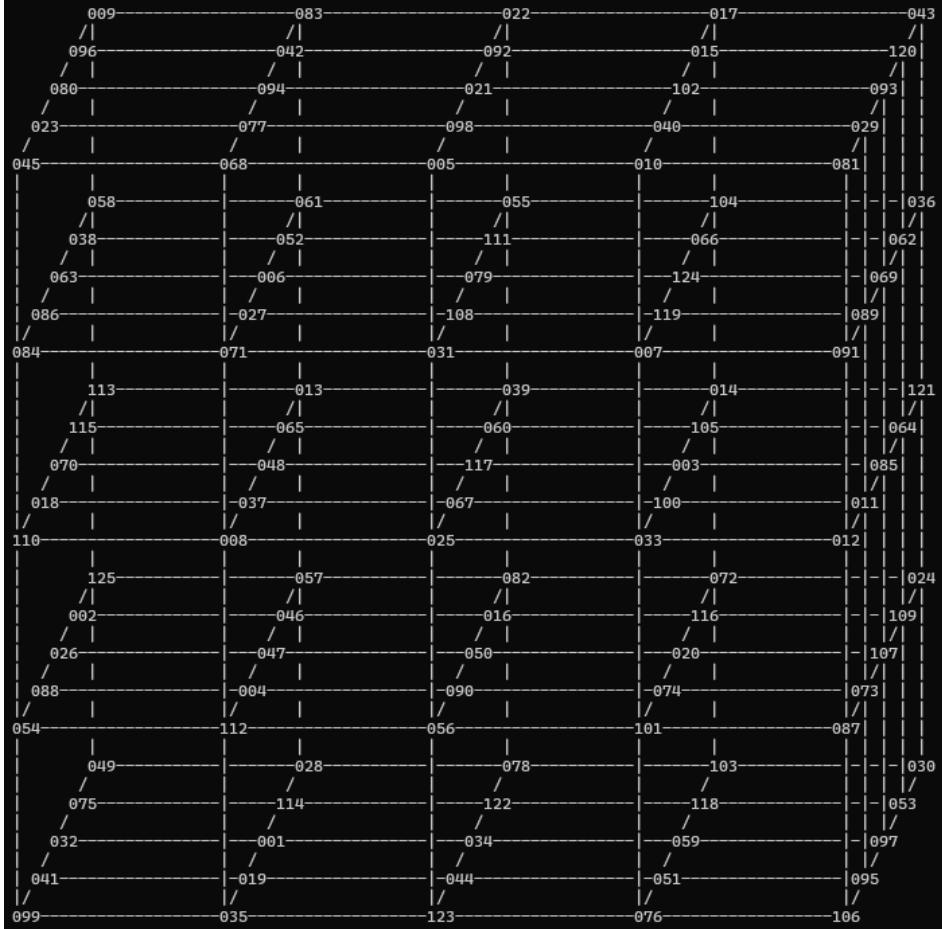


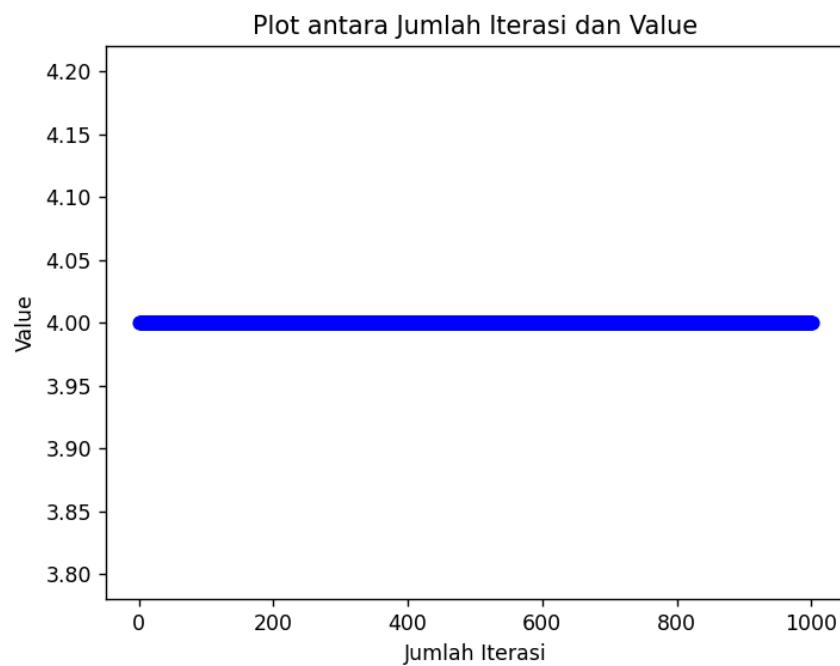
Jumlah populasi	100
Banyak	50000

iterasi	
Durasi	73.617s

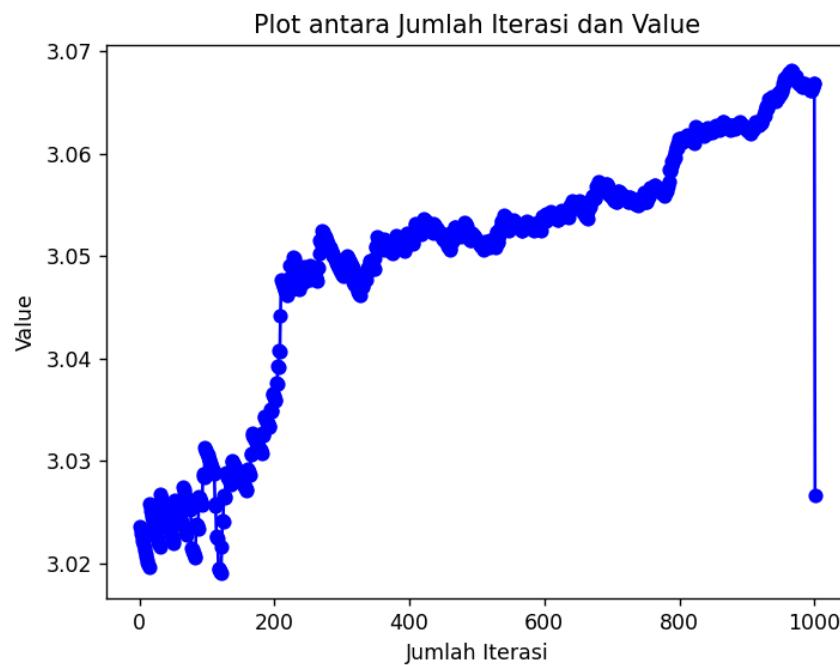
Eksperimen 2-1, iterasi sebagai kontrol

State Awal						
009	083	022	017	043		
/	/	/	/	/		
096	042	092	015	120		
/	/	/	/	/		
080	094	021	102	093		
/	/	/	/	/		
023	077	098	040	073		
/	/	/	/	/		
045	068	005	010	081		
/	/	/	/	/		
058	061	055	104	036		
/	/	/	/	/		
038	052	111	066	062		
/	/	/	/	/		
063	006	079	124	069		
/	/	/	/	/		
086	027	108	119	089		
/	/	/	/	/		
084	071	031	007	091		
/	/	/	/	/		
113	013	039	014	121		
/	/	/	/	/		
115	065	060	105	064		
/	/	/	/	/		
070	048	117	003	085		
/	/	/	/	/		
018	037	067	100	011		
/	/	/	/	/		
110	008	025	033	012		
/	/	/	/	/		
125	057	082	072	024		
/	/	/	/	/		
002	046	016	116	109		
/	/	/	/	/		
026	047	050	020	187		
/	/	/	/	/		
088	004	090	074	029		
/	/	/	/	/		
054	112	056	101	087		
/	/	/	/	/		
049	028	078	103	030		
/	/	/	/	/		
075	114	122	118	053		
/	/	/	/	/		
032	001	034	059	097		
/	/	/	/	/		
041	019	044	051	095		
/	/	/	/	/		
099	035	123	076	106		

State Akhir	
Nilai Akhir Objective Function	4
Plot (objective function)	Nilai maksimum



Nilai rata-rata



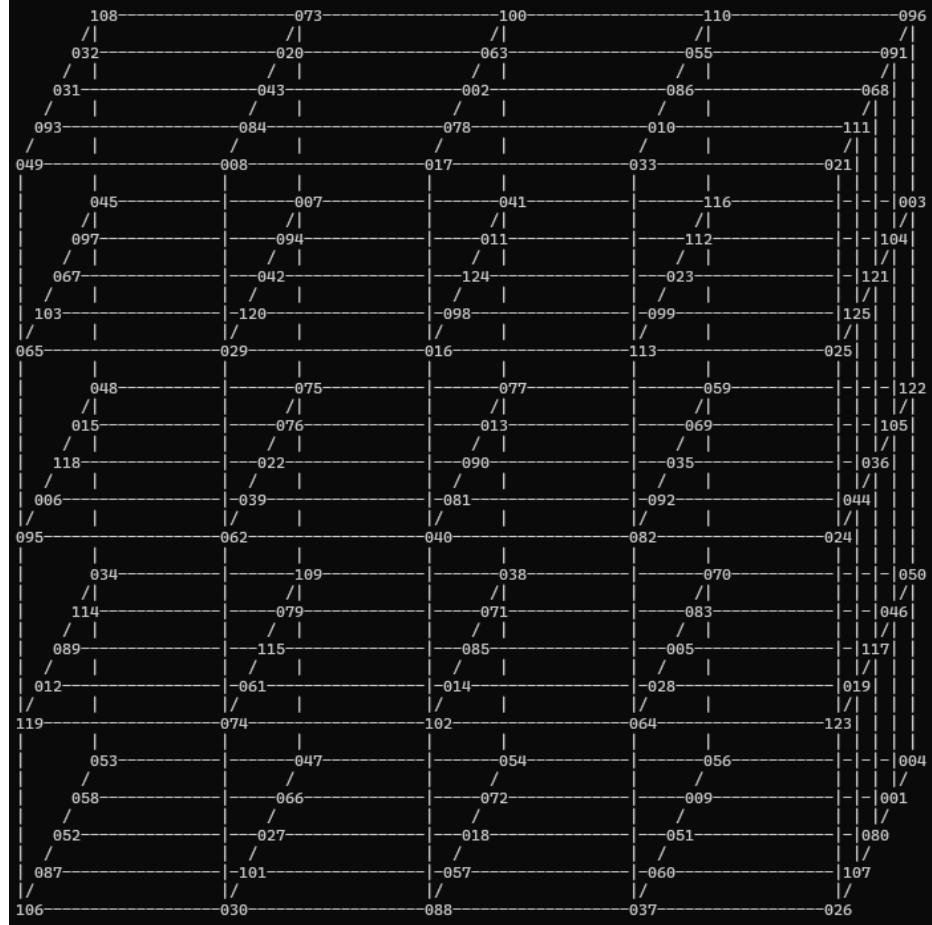
Jumlah populasi	125
Banyak	1000

iterasi	
Durasi	0.176s

Eksperimen 2-2, iterasi sebagai kontrol

State Awal	Diagram State Transitions
	<pre> graph TD S1[108] --- S2[073] S1 --- S3[020] S1 --- S4[063] S1 --- S5[100] S1 --- S6[055] S1 --- S7[110] S1 --- S8[096] S1 --- S9[091] S2 --- S10[032] S2 --- S11[043] S2 --- S12[002] S2 --- S13[068] S2 --- S14[086] S2 --- S15[010] S2 --- S16[111] S2 --- S17[021] S3 --- S18[031] S3 --- S19[084] S3 --- S20[078] S3 --- S21[017] S3 --- S22[033] S3 --- S23[116] S3 --- S24[007] S3 --- S25[041] S4 --- S26[093] S4 --- S27[084] S4 --- S28[078] S4 --- S29[010] S4 --- S30[111] S4 --- S31[021] S5 --- S32[049] S5 --- S33[008] S5 --- S34[017] S5 --- S35[033] S5 --- S36[116] S5 --- S37[003] S6 --- S38[045] S6 --- S39[097] S6 --- S40[094] S6 --- S41[011] S6 --- S42[112] S6 --- S43[104] S7 --- S44[067] S7 --- S45[042] S7 --- S46[124] S7 --- S47[023] S7 --- S48[121] S8 --- S49[103] S8 --- S50[120] S8 --- S51[098] S8 --- S52[099] S8 --- S53[125] S9 --- S54[065] S9 --- S55[029] S9 --- S56[016] S9 --- S57[113] S9 --- S58[025] S10 --- S59[048] S10 --- S60[075] S10 --- S61[077] S10 --- S62[059] S10 --- S63[122] S11 --- S64[015] S11 --- S65[076] S11 --- S66[027] S11 --- S67[069] S11 --- S68[105] S12 --- S69[118] S12 --- S70[022] S12 --- S71[090] S12 --- S72[035] S12 --- S73[036] S13 --- S74[006] S13 --- S75[039] S13 --- S76[081] S13 --- S77[092] S13 --- S78[044] S14 --- S79[095] S14 --- S80[062] S14 --- S81[040] S14 --- S82[082] S14 --- S83[024] S15 --- S84[034] S15 --- S85[109] S15 --- S86[038] S15 --- S87[070] S15 --- S88[050] S16 --- S89[114] S16 --- S90[079] S16 --- S91[071] S16 --- S92[083] S16 --- S93[046] S17 --- S94[089] S17 --- S95[115] S17 --- S96[085] S17 --- S97[005] S17 --- S98[117] S18 --- S99[012] S18 --- S100[061] S18 --- S101[014] S18 --- S102[028] S18 --- S103[019] S19 --- S104[119] S19 --- S105[074] S19 --- S106[102] S19 --- S107[064] S19 --- S108[123] S20 --- S109[053] S20 --- S110[047] S20 --- S111[054] S20 --- S112[056] S20 --- S113[004] S21 --- S114[058] S21 --- S115[066] S21 --- S116[072] S21 --- S117[009] S21 --- S118[001] S22 --- S119[052] S22 --- S120[013] S22 --- S121[018] S22 --- S122[051] S22 --- S123[080] S23 --- S124[087] S23 --- S125[101] S23 --- S126[057] S23 --- S127[060] S23 --- S128[107] S24 --- S129[106] S24 --- S130[030] S24 --- S131[088] S24 --- S132[037] S24 --- S133[026] </pre>

State Akhir

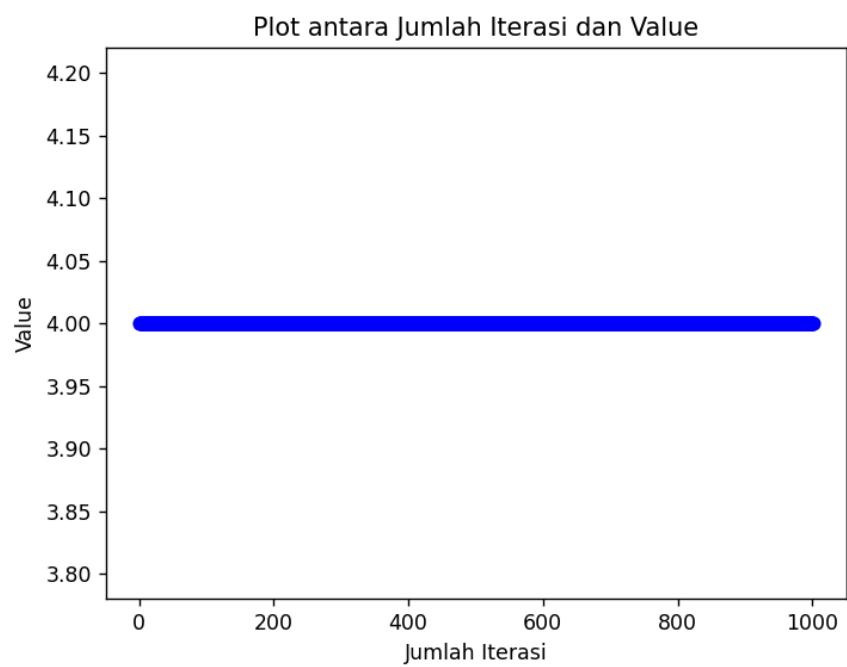


Nilai Akhir
Objective
Function

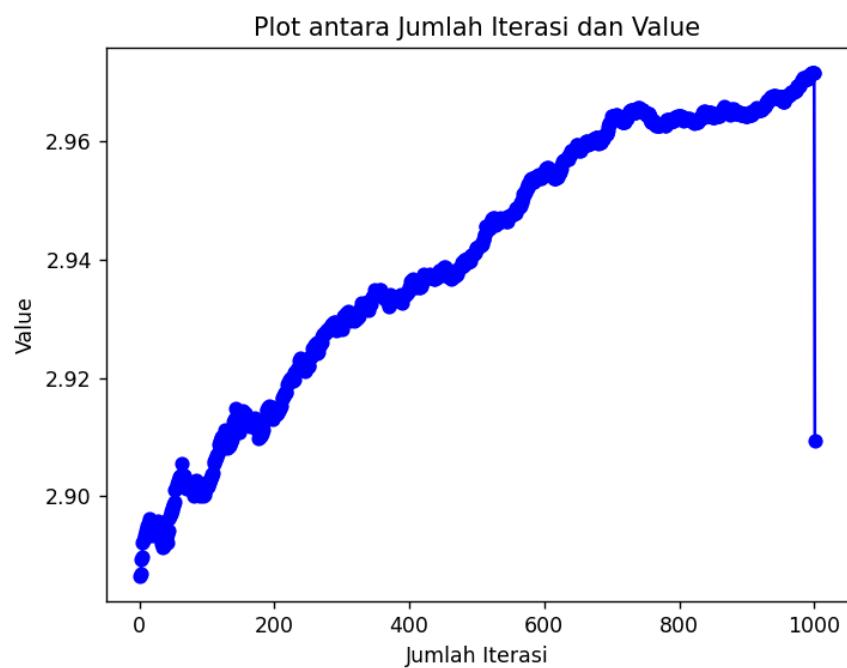
4

Plot
(objective
function)

Nilai maksimum



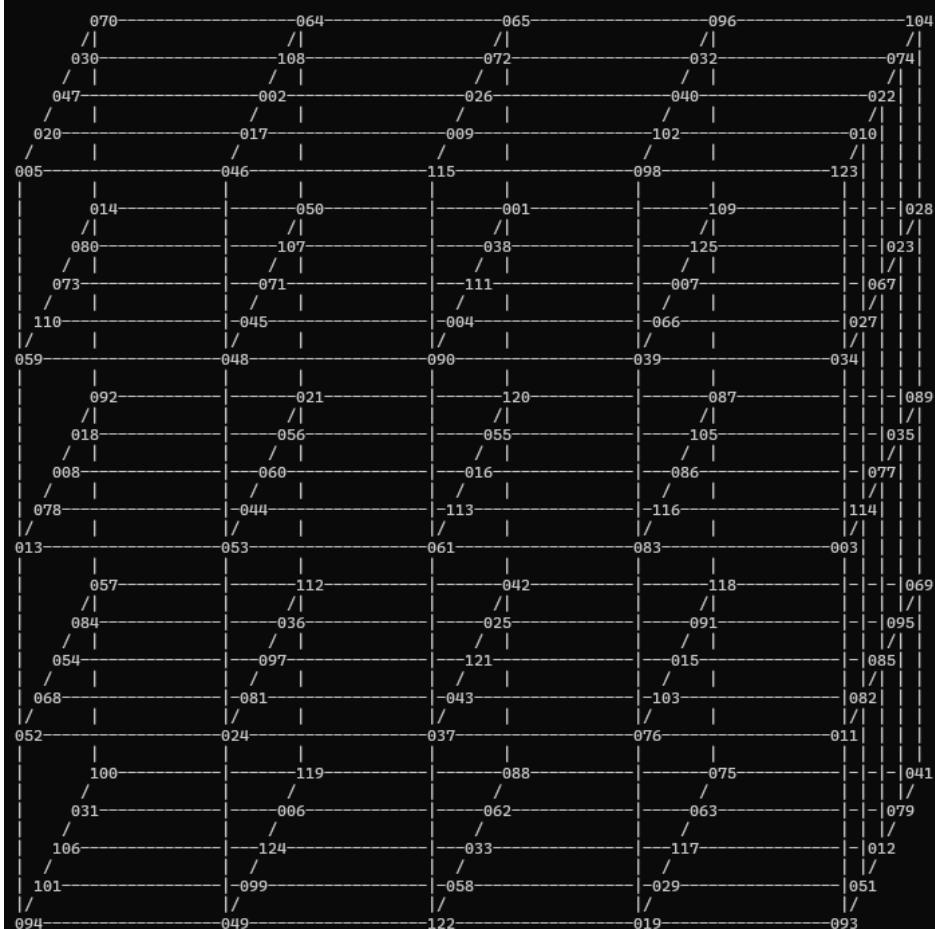
Nilai rata-rata



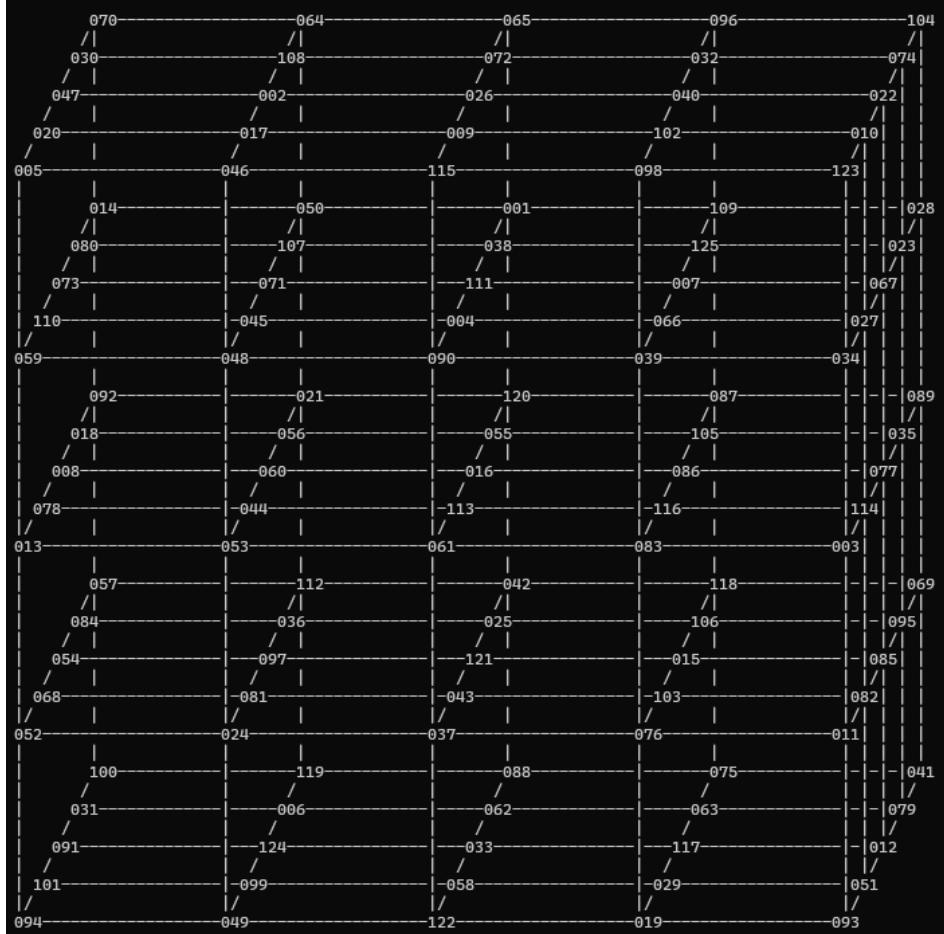
Jumlah populasi	500
Banyak iterasi	1000

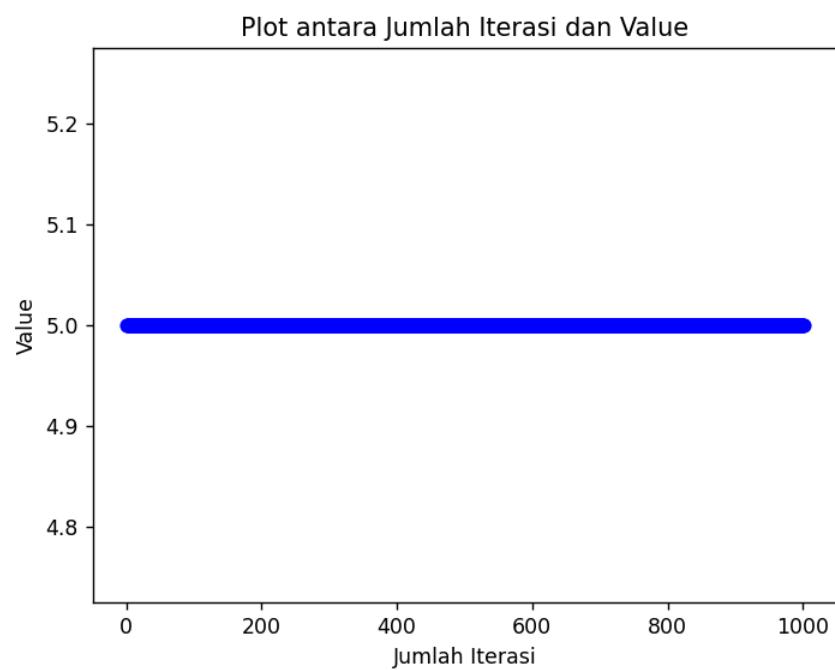
Durasi	0.257s
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Eksperimen 2-3, iterasi sebagai kontrol

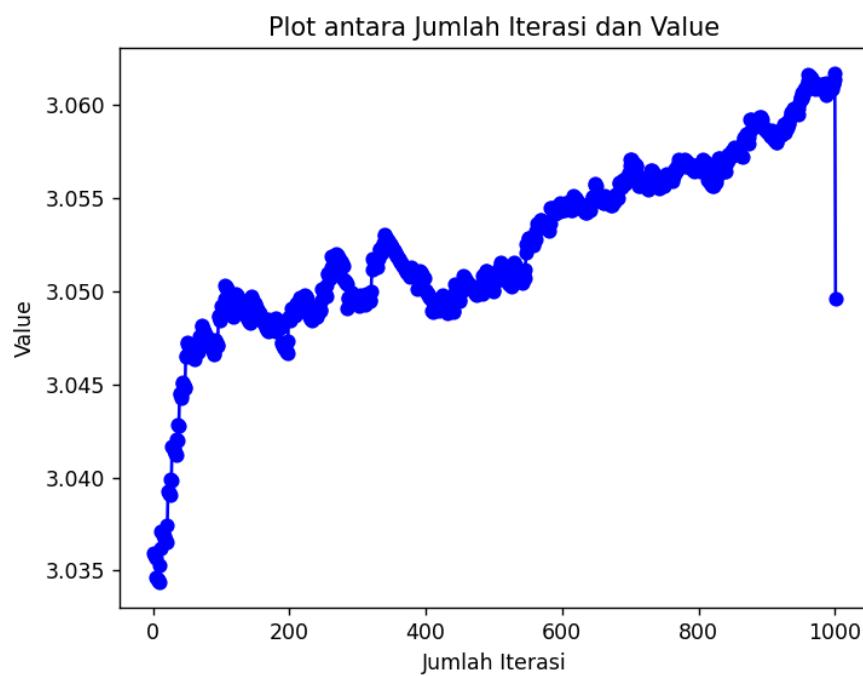
State Awal	
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State Akhir





Nilai rata-rata



Jumlah populasi	1000
Banyak	1000

iterasi	
Durasi	0.172s

2.3.2. Analisis

- Setiap algoritma memiliki jarak yang lumayan jauh dari global optima teoritis yaitu 109, tiap algoritma dengan waktu dijalankan hanya < 1 menit hanya dapat mendapatkan nilai maksimal sekitar 3. Hal ini dikarenakan berbagai hal seperti kurangnya iterasi yang dilakukan, dan kemungkinan yang cukup kecil untuk naik ke global optima (mengingat bahwa ada 3844 total state yang mungkin, sedangkan hanya ada 1 global optima).
- Untuk Hill Climb, dengan parameter yang tepat dapat dihasilkan hasil yang mirip pada setiap varian.
- Pada Algoritma Hill Climb, variasi stochastic dapat menghasilkan hasil akhir yang sama dengan waktu yang jauh lebih cepat dibandingkan ke 3 varian lainnya yang cukup mirip.
- Untuk Hill Climb Steepest Ascent didapatkan hasil yang cukup konsisten dimana waktu sekitar 20-30 detik, banyak iterasi 30-40, dan nilai akhir objective 30-40. Untuk Hill Climb with Sideways Move dengan maksimum sideways move 5-10 tetap didapat hasil yang cukup konsisten dimana waktu sekitar 20-30 detik, banyak iterasi 30-40, dan nilai akhir objective 30-40. Hill Climb Random Restart waktunya proporsional dengan banyaknya restart yang diinputkan, banyak iterasi di sekitar 30, dan nilai akhir di sekitar 40. Untuk Hill Climb Stochastic bisa didapatkan nilai objektif akhir 30-40 dengan waktu < 5 detik dengan jumlah langkah maksimal 10000-50000.
- Pada Algoritma Simmulated Annealing, nilai objektif konsisten dihasilkan dalam range 17-22, dengan frekuensi stuck sekitar 980, dan waktu sekitar 0.05 detik. Plot nilai objektif menunjukkan bentuk tangga naik. Tidak adanya nilai objektif yang turun mungkin disebabkan fungsi schedule $T = 0.6^{t-1}$ yang menurunkan temperatur secara cepat. Plot nilai exp(deltaE/T) menunjukkan nilainya sering berganti antara 0 dan 1, dan sangat jarang berada diantaranya. Terlihat pula Simmulated Annealing mirip dengan stochastic hill climbing, terutama jika dibandingkan dengan maksimum iterasi 1000, dengan nilai objektif 18 dan kecepatan 0.025.
- Pada Algoritma Genetik, nilai objektif yang dihasilkan merupakan yang paling rendah dibandingkan algoritma lain, yaitu rata-rata hanya 5-7 dan hanya meningkat 0-1 dari nilai objektif pada state awalnya, untuk jumlah iterasi dibawah 10000 (sekitar 2 detik). Hal ini terjadi karena Algoritma Genetik berdasarkan pada konsep *breeding*/penurunan gen di dunia asli. Karena penurunan gen, anak dari state *parent* yang dipilih akan cenderung mirip dengan kedua *parentnya*, sehingga sangat susah untuk meningkatkan nilai fungsi objektif di algoritma ini.
- Menurut hasil eksperimen, banyak iterasi dan jumlah populasi awal pada Algoritma Genetik masing-masing berbanding lurus dengan nilai objective function akhir. Perubahan jumlah iterasi memiliki peningkatan yang lebih teratur dan terlihat dibandingkan perubahan jumlah populasi awal. Peningkatan nilai akhir dari perubahan

jumlah iterasi berbentuk kurva logaritmik, yang berarti peningkatan tersebut akan menjadi stagnan setelah jumlah iterasi tertentu.

Bab 3: Kesimpulan dan Saran

3.1. Kesimpulan

Kesimpulan yang kita dapat dari membandingkan seluruh algoritma yang digunakan untuk melakukan local search, yaitu kita dapat mengetahui setiap algoritma mempunyai kelebihannya masing-masing. Sebagai contoh, hill-climb secara general menghasilkan solusi yang cukup optimal dan konsisten, namun sangat jarang mencapai solusi yang mendekati global optimum. Untuk kasus simulated annealing dan genetic algorithm, walaupun solusi yang dihasilkan tidak konsisten, tetapi ada kemungkinan solusi yang didapatkan mendekati global optima (walaupun kemungkinannya juga kecil).

3.2. Saran

Sebaiknya melakukan riset tech stack terlebih dahulu untuk mencari tech stack mana yang paling optimal untuk mengerjakan persoalan yang diberikan. Selain itu juga sebaiknya tidak memulai tugas ini H-1.

Pembagian tugas tiap anggota kelompok

No	NIM	Tugas
1	13522010	Genetic Algorithm
2	13522044	Primitif magicCube, Plotting
3	13522059	Steepest Ascent, Sideway Move, Random Restart, dan Stochastic Hill Climbing
4	13522065	Simulated Annealing

Referensi

<https://www.magischvierkant.com/three-dimensional-eng/5x5x5/half-pandiagonal-shift/>