EAS

July 5, 2021

[1]:
```
# Hanya diperlukan untuk keperluan development
# import sys
# from google.colab import drive
# drive.mount('/content/drive/', force_remount=True)
# sys.path.append('/content/drive/My Drive/Colab Notebooks/EAS AB')
```

0.1 Pustaka

[2]:
```
from dataset import *
from IPython.display import display
import math
import pandas as pd
import random
import time

# Hanya diperlukan untuk keperluan development
# !pip install ortools
from ortools.constraint_solver import routing_enums_pb2
from ortools.constraint_solver import pywrapcp
```

0.2 Fungsi Bantuan

[3]:
```
def get_distance(x, y, map):
  return map[x][y]

def total_distance(individu, map):
  distance = 0

  for idx in range(len(individu)):
    if idx == (len(individu)-1):
      break
    else:
      distance += get_distance( individu[idx], individu[idx+1], map)
  return distance

def slice_idx(dataset_length):
  idx = [random.randrange(dataset_length) for i in range(2)]
  return [min(idx), max(idx)]
```

```
def average_list(lst):
  return sum(lst) / len(lst)

def pdbest(best, bks):
  return ((best - bks)/bks)*100

def pdav(avg, bks):
  return ((avg - bks)/bks)*100
```

0.3 Fungsi Populasi

[4]:
```
def map_gen(dataset):
  w, h = len(dataset), len(dataset)
  map = [[0 for x in range(w)] for y in range(h)]

  for i in range(len(dataset)):
    for j in range(len(dataset)):
      x1 = dataset[i][1]
      x2 = dataset[j][1]
      y1 = dataset[i][2]
      y2 = dataset[j][2]
      map[i][j] = round(math.sqrt(((x2-x1)**2) + ((y2-y1)**2)), 2)

  return map

def individu_gen(dataset_length):
  return random.sample( [i for i in range(dataset_length)], dataset_length )

def population_gen(dataset_length, number_of_population):
  population = []
  for i in range(number_of_population):
    population.append(individu_gen(dataset_length))
  return population
```

0.4 Fungsi Visualisasi

[5]:
```
def map_as_table(map, **kwargs):
  df = pd.DataFrame(data=map)

  if "columns" in kwargs:
    df.columns = kwargs.get("columns")
  else:
    df.columns+=1

  if "index" in kwargs:
    df.index = kwargs.get("index")
```

```
  else:
    df.index+=1

  display(df)

def plot(title, **kwargs):
  index = ['eil51', 'berlin52', 'st70', 'eil76', 'rat99', 'kroA100', 'kroB100',␣
↪'kroC100', 'kroD100', 'kroE100', 'eil101', 'pr107', 'pr124', 'pr136',␣
↪'pr144']
  df = pd.DataFrame(kwargs,
                    index=index)

  ax = df.plot.bar(rot=0, figsize=(15, 15))
  ax.set_title(title)
```

0.5 Fungsi Algoritma Genetika

[6]:
```
def fitness(individu, map):
  distance = total_distance(individu, map)
  return ((1/distance), individu , distance)

def grade(population, map, fitness):
  graded = []
  for individu in population:
    graded.append(fitness(individu, map))
  return [i[1] for i in sorted(graded, reverse=True)]

def crossover(a, b):
  div_idx_1, div_idx_2 = slice_idx(len(a))
  slices = a[div_idx_1:div_idx_2]
  not_in_slices = [i for i in b if i not in slices]
  offspring = not_in_slices[0:div_idx_1] + slices + not_in_slices[div_idx_1:]
  return offspring

def mutate(individu, chance_to_mutate) :
  mutant = individu[:]
  r = random.random()
  first_idx = random.randint(0, len(individu)-1)
  second_idx = random.randint(0, len(individu)-1)
  if chance_to_mutate > r:
    mutant[first_idx],mutant[second_idx] = mutant[second_idx],mutant[first_idx]
  return mutant

def selection(population):
    return population[:2]
```

```
def genetic_algorithm(dataset):
  map = map_gen(dataset)

  NUMBER_OF_POPULATION = 50
  NUMBER_OF_GENERATION = 1000
  CHANCE_TO_MUTATE = 1

  population = population_gen(len(dataset), NUMBER_OF_POPULATION)
  best_individu = None

  for generation in range(NUMBER_OF_GENERATION):
    graded_population = grade(population, map, fitness)[:49]

    grade_one, grade_two = selection(graded_population)

    best_individu = grade_one[:]

    child = crossover(grade_one, grade_two)
    mutant = mutate(child, CHANCE_TO_MUTATE)
    population = graded_population[:49]
    population.append(mutant)


  best_distance = total_distance(best_individu, map)
  return best_distance
```

0.6 Fungsi Google OR-Tools

[7]:
```
def create_data_model(map):
  data = {}
  data['distance_matrix'] = map
  data['num_vehicles'] = 1
  data['depot'] = 0
  return data

def or_tools(dataset):
  map = map_gen(dataset)
  data = create_data_model(map)

  manager = pywrapcp.RoutingIndexManager(len(data['distance_matrix']),
                                         data['num_vehicles'], data['depot'])

  routing = pywrapcp.RoutingModel(manager)

  distance_matrix = data['distance_matrix']

  def distance_callback(from_index, to_index):
```

```
    from_node = manager.IndexToNode(from_index)
    to_node = manager.IndexToNode(to_index)
    return distance_matrix[from_node][to_node]

  transit_callback_index = routing.RegisterTransitCallback(distance_callback)

  routing.SetArcCostEvaluatorOfAllVehicles(transit_callback_index)

  search_parameters = pywrapcp.DefaultRoutingSearchParameters()
  search_parameters.first_solution_strategy = (
      routing_enums_pb2.FirstSolutionStrategy.PATH_CHEAPEST_ARC)

  solution = routing.SolveWithParameters(search_parameters)

  best = solution.ObjectiveValue()
  return best
```

0.7 Fungsi Benchmark

[8]:
```
def bench(count, dataset, bks, method='ga'):
  best_pool = []
  if method == 'ga':
    func = genetic_algorithm
  elif method == 'or-tools':
    func = or_tools
  for i in range(count):
    best_pool.append(func(dataset))

  best = min(best_pool)
  avg = average_list(best_pool)

  dataset_pdbest = pdbest(best, bks)
  dataset_pdavg = pdav(avg, bks)
  return [bks, avg, best, dataset_pdavg, dataset_pdbest]
```

[9]:
```
def main():
  BENCHMARK_ITERATION = 10
  sos_pdav = [ 2.99, 1.56, 3.57, 3.4, 7.13, 1.65, 4.529, 1.31, 3.52, 1.81, 4.
↪88, 4.08, 17.25, 3.81, 2.73 ]
  sos_pdbest = [0.7, 1.39, 0, 0.74, 6.03, 0.56, 0.07, 0.3, 0.93, 0.27, 3.18, 4.
↪05, 16.79, 1.29, 0.09]
  dsos_pdav = [ 0.45, 0.01, 0.62, 1.75, 2.46, 0.60, 0.90, 0.64, 0.94, 0.74, 3.
↪43, 0.32, 0.68, 0.93, 0.49]
  dsos_pdbest = [0, 0, 0, 0.74, 1.98, 0, 0, 0, 0, 0, 1.75, 0.02, 0, 0.69, 0.05]

  # Genetic Algorithm
  ga_results = []
```

```
ga_pdbest = []
ga_pdav = []
start = time.time()
for dataset in dataset_list:
  print(f'Current dataset: {dataset[2]}')
  benchmark = bench(BENCHMARK_ITERATION, dataset[0], dataset[1], 'ga')
  benchmark.insert(0,dataset[2])
  ga_pdbest.append(benchmark[5])
  ga_pdav.append(benchmark[4])
  ga_results.append(benchmark)
end = time.time()
total_t = time.gmtime((end - start))
print (f'Time elapsed: {total_t.tm_min}m {total_t.tm_min}s')


# Google OR-Tools
gor_results = []
gor_pdbest = []
gor_pdav = []
start = time.time()
for dataset in dataset_list:
  print(f'Current dataset: {dataset[2]}')
  benchmark = bench(BENCHMARK_ITERATION, dataset[0], dataset[1], 'or-tools')
  benchmark.insert(0,dataset[2])
  gor_pdbest.append(benchmark[5])
  gor_pdav.append(benchmark[4])
  gor_results.append(benchmark)
end = time.time()
total_t = time.gmtime((end - start))
print (f'Time elapsed: {total_t.tm_min}m {total_t.tm_min}s')



map_as_table(ga_results, columns=['Name', 'BKS', 'Average', 'Best',␣
↪'PDAv(%)', 'PDBest(%)'])
map_as_table(gor_results, columns=['Name', 'BKS', 'Average', 'Best',␣
↪'PDAv(%)', 'PDBest(%)'])

plot("SOS vs DSOS vs GA PDBest ", sos=sos_pdbest, dsos=dsos_pdbest,␣
↪ga=ga_pdbest)
plot("SOS vs DSOS vs G-OR PDBest ", sos=sos_pdbest, dsos=dsos_pdbest,␣
↪gor=gor_pdbest)
plot("GA vs G-OR PDBest ", ga=ga_pdbest, gor=gor_pdbest)

plot("SOS vs DSOS vs GA PDAv", sos=sos_pdav, dsos=dsos_pdav, ga=ga_pdav)
plot("SOS vs DSOS vs G-OR PDAv", sos=sos_pdav, dsos=dsos_pdav, gor=gor_pdav)
plot("GA vs G-OR PDAv", ga=ga_pdav, gor=gor_pdav)
```

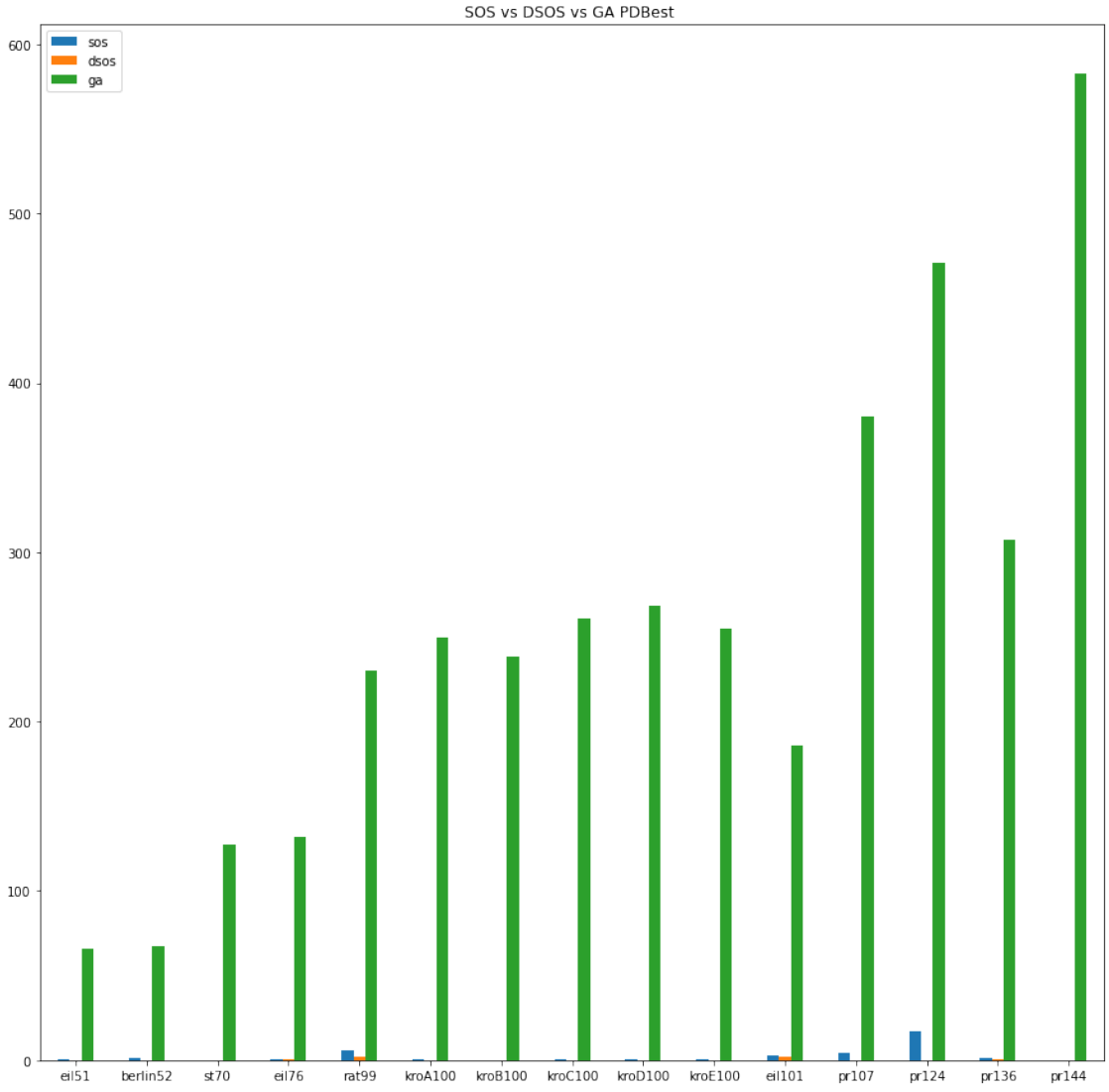
```
main()
```

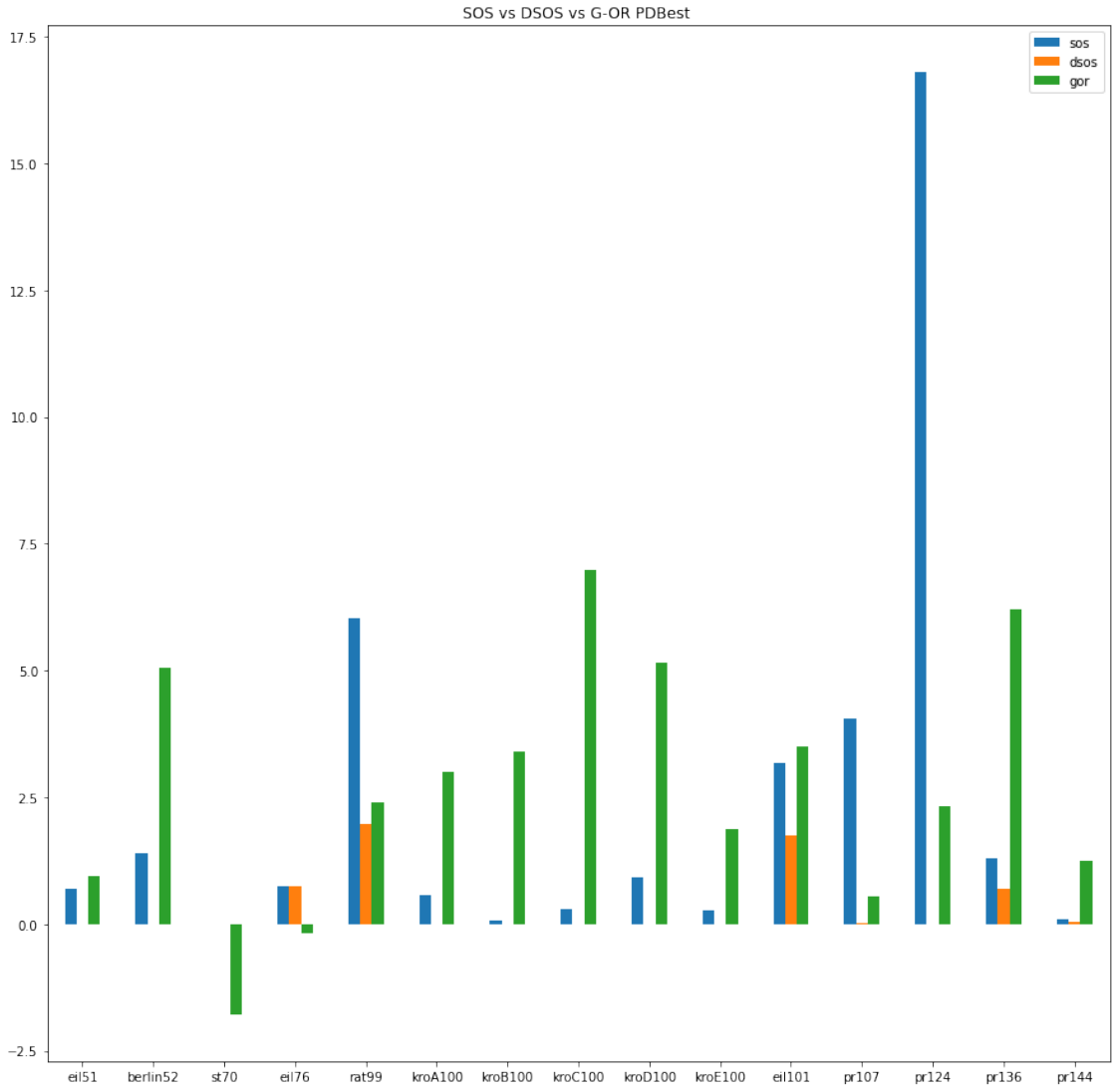
```
Current dataset: eil51
Current dataset: berlin52
Current dataset: st70
Current dataset: eil76
Current dataset: rat99
Current dataset: kroA100
Current dataset: kroB100
Current dataset: kroC100
Current dataset: kroD100
Current dataset: kroE100
Current dataset: eil101
Current dataset: pr107
Current dataset: pr124
Current dataset: pr136
Current dataset: pr144
Time elapsed: 2m 2s
Current dataset: eil51
Current dataset: berlin52
Current dataset: st70
Current dataset: eil76
Current dataset: rat99
Current dataset: kroA100
Current dataset: kroB100
Current dataset: kroC100
Current dataset: kroD100
Current dataset: kroE100
Current dataset: eil101
Current dataset: pr107
Current dataset: pr124
Current dataset: pr136
Current dataset: pr144
Time elapsed: 1m 1s
```

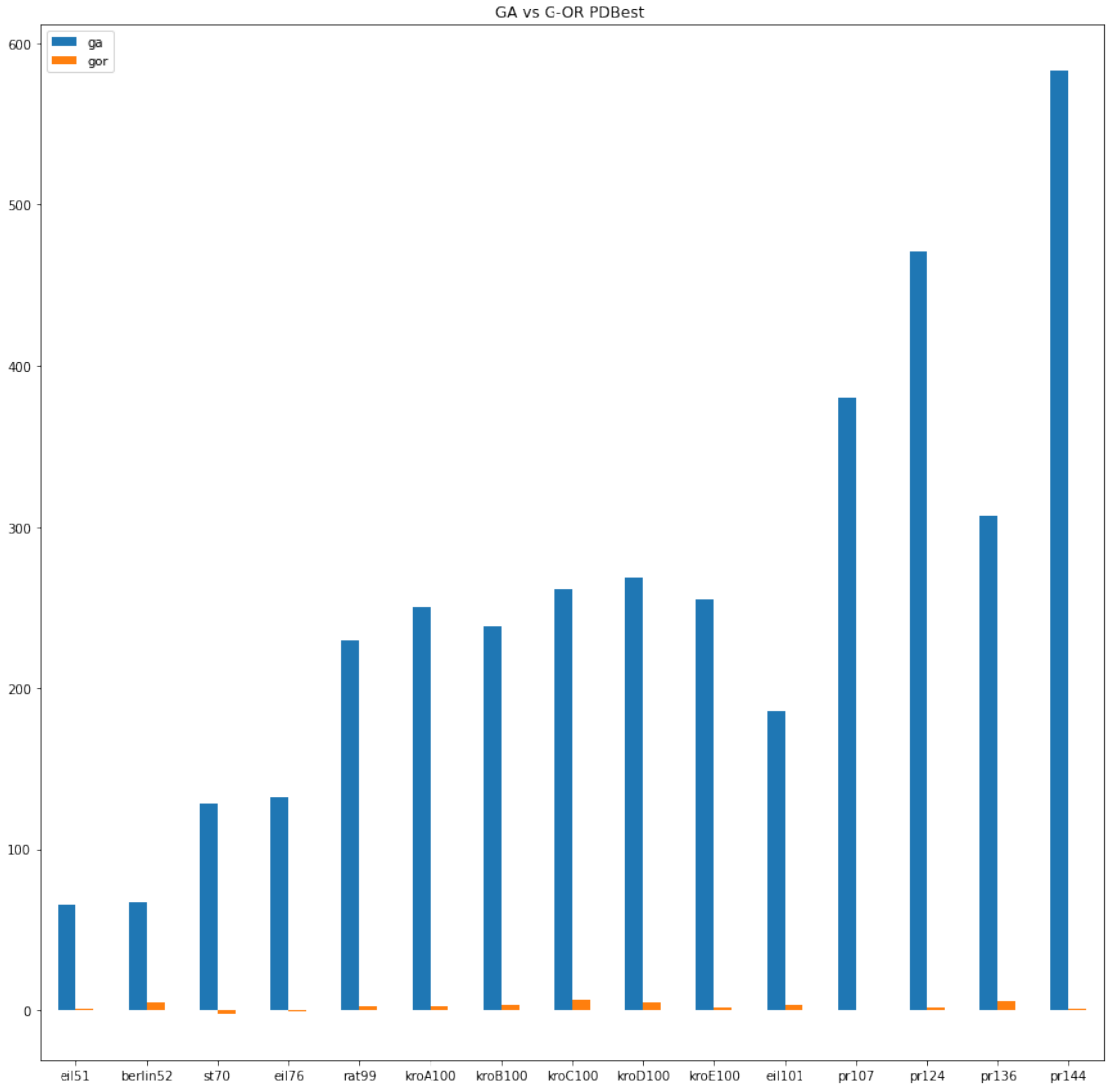
	Name	BKS	Average	Best	PDAv(%)	PDBest(%)
1	eil51	426	778.892	707.17	82.838498	66.002347
2	berlin52	7542	13703.183	12646.11	81.691634	67.675815
3	st70	675	1782.446	1536.93	164.066074	127.693333
4	eil76	538	1320.765	1248.76	145.495353	132.111524
5	rat99	1211	4232.247	3997.02	249.483650	230.059455
6	kroA100	21282	82189.507	74483.15	286.192590	249.981910
7	kroB100	22140	84417.411	74954.91	281.289119	238.549729
8	kroC100	20749	83233.481	74922.16	301.144542	261.088052
9	kroD100	21294	82703.661	78413.35	288.389504	268.241523
10	kroE100	22068	85665.784	78372.86	288.190067	255.142559
11	eil101	629	1881.413	1796.22	199.111765	185.567568

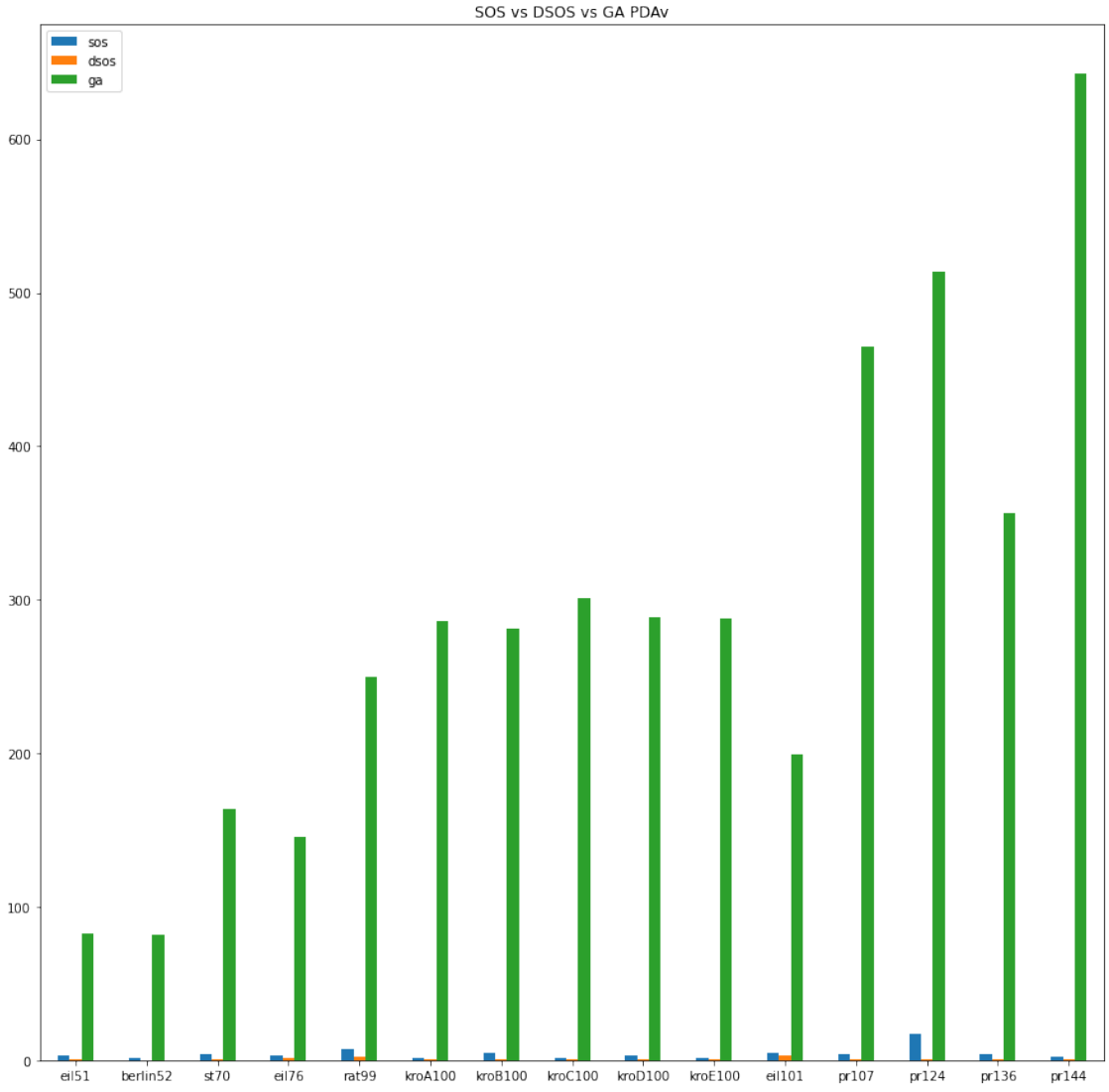
12	pr107	44303	250341.103	212791.61	465.065804	380.309708
13	pr124	59030	362162.778	337119.19	513.523256	471.098069
14	pr136	96772	442076.106	393942.96	356.822331	307.083619
15	pr144	58537	434669.418	399498.30	642.554996	582.471428

	Name	BKS	Average	Best	PDAv(%)	PDBest(%)
1	eil51	426	430.0	430	0.938967	0.938967
2	berlin52	7542	7924.0	7924	5.064970	5.064970
3	st70	675	663.0	663	-1.777778	-1.777778
4	eil76	538	537.0	537	-0.185874	-0.185874
5	rat99	1211	1240.0	1240	2.394715	2.394715
6	kroA100	21282	21923.0	21923	3.011935	3.011935
7	kroB100	22140	22892.0	22892	3.396567	3.396567
8	kroC100	20749	22198.0	22198	6.983469	6.983469
9	kroD100	21294	22392.0	22392	5.156382	5.156382
10	kroE100	22068	22479.0	22479	1.862425	1.862425
11	eil101	629	651.0	651	3.497615	3.497615
12	pr107	44303	44547.0	44547	0.550753	0.550753
13	pr124	59030	60397.0	60397	2.315772	2.315772
14	pr136	96772	102782.0	102782	6.210474	6.210474
15	pr144	58537	59272.0	59272	1.255616	1.255616


SOS vs DSOS vs GA PDBest
sos
dsos
ga
600
500
400
300
200
100
0
eil51
berlin52
st70
eil76
rat99
kroA100
kroB100
kroC100
kroD100
kroE100
eil101
pr107
pr124
pr136
pr144


SOS vs DSOS vs G-OR PDBest
sos
dsos
gor
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
eil51
berlin52
st70
eil76
rat99
kroA100
kroB100
kroC100
kroD100
kroE100
eil101
pr107
pr124
pr136
pr144


GA vs G-OR PDBest
ga
gor
600
500
400
300
200
100
0
eil51
berlin52
st70
eil76
rat99
kroA100
kroB100
kroC100
kroD100
kroE100
eil101
pr107
pr124
pr136
pr144


SOS vs DSOS vs GA PDAv
sos
dsos
ga
600
500
400
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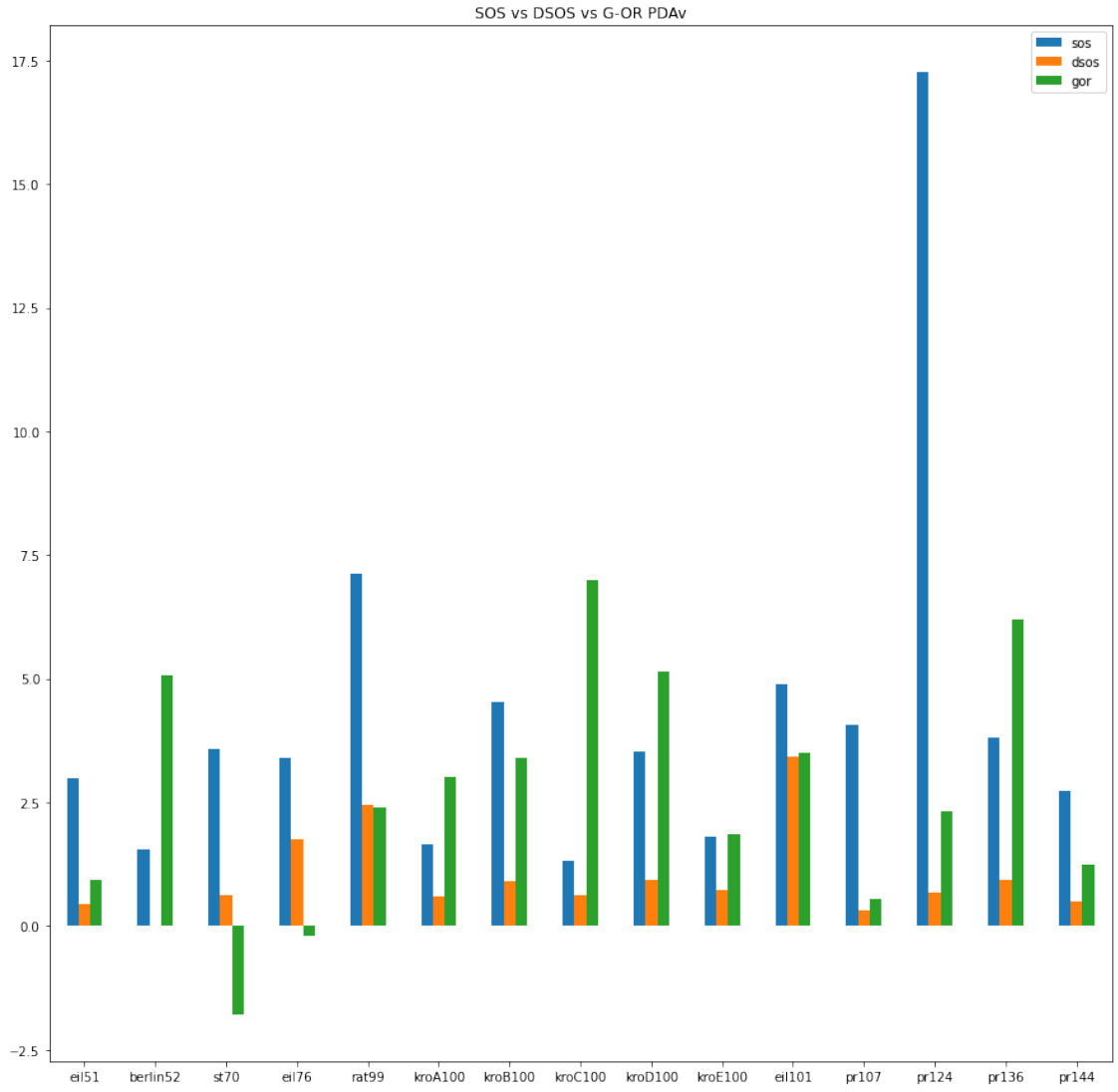
eil51
berlin52
st70
eil76
rat99
kroA100
kroB100
kroC100
kroD100
kroE100
eil101
pr107
pr124
pr136
pr144


SOS vs DSOS vs G-OR PDAv
sos
dsos
gor
17.5
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eil51
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rat99
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kroB100
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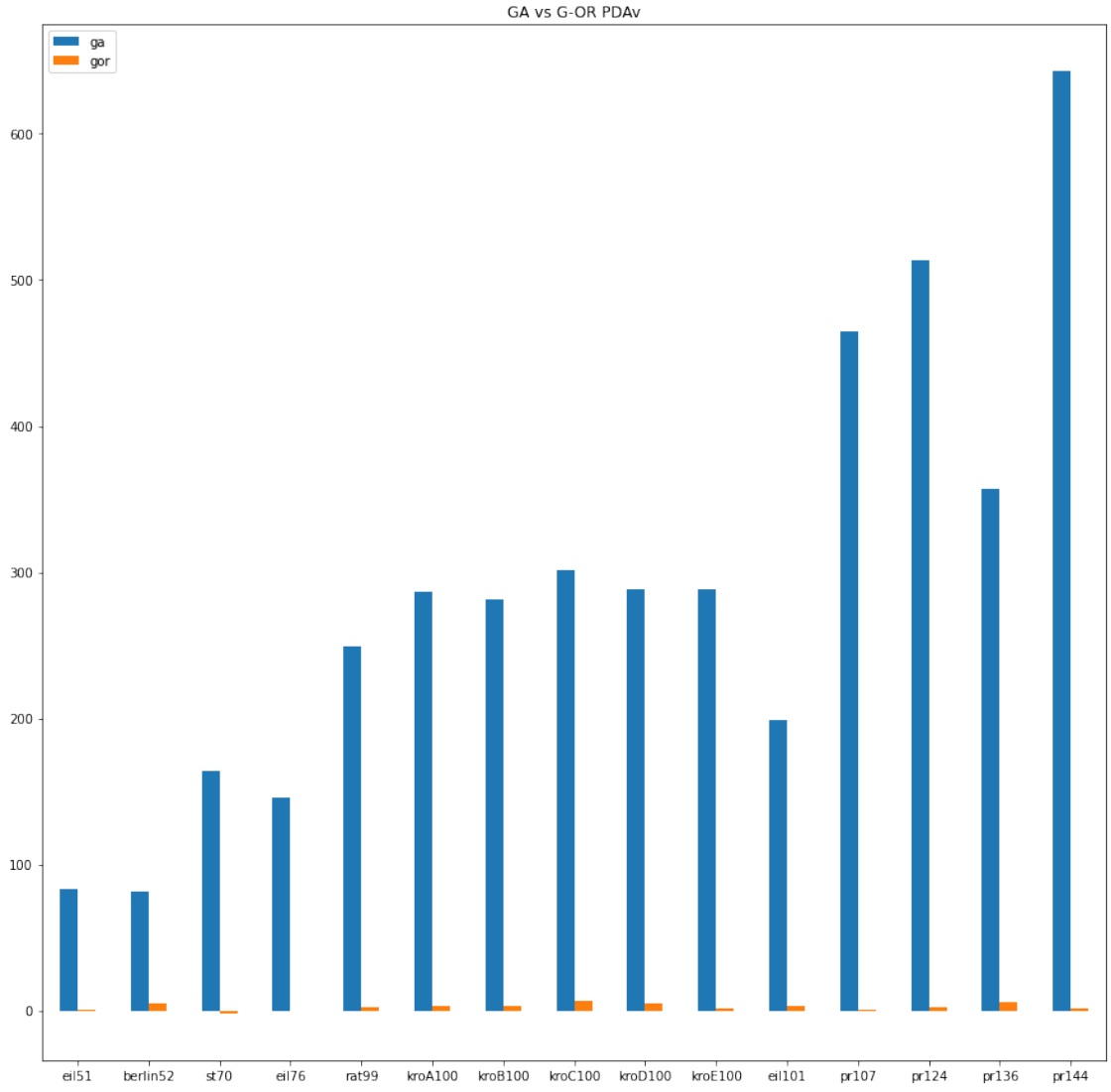
kroD100
kroE100
eil101
pr107
pr124
pr136
pr144


GA vs G-OR PDAv
ga
gor
600
500
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0
eil51
berlin52
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kroA100
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