Computer Work

Evolutionary Multi-objective Optimization

NSGAII

ULPGC

Master's Degree in Intelligent Systems and Numerical Applications in Engineering

Optimal Engineering Design

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Objectives:

1. To use an evolutionary multi-objective optimization software.
2. To execute different parameters in a test case: variation of population size and mutation rate should be considered at minimum.
3. To analyze and evaluate the effect of the chosen parameter set in the algorithm convergence by using the hypervolume metric.
4. To find a combination of parameter for each problem, which achieves good results (at least population size and mutation rate should be tested in a 3x3 combination set: 3 values of population size and 3 values of mutation rate, resulting in 9 parameter combinations).

Procedure:

1. In the computer laboratory, students follow the professor instructions.
2. They allow to guide step by step in a common mathematical test case.
3. Later, the students will apply these to other functions chosen by themself.
4. A report must be written with the process, results, and conclusions.

The minimum content of the report:

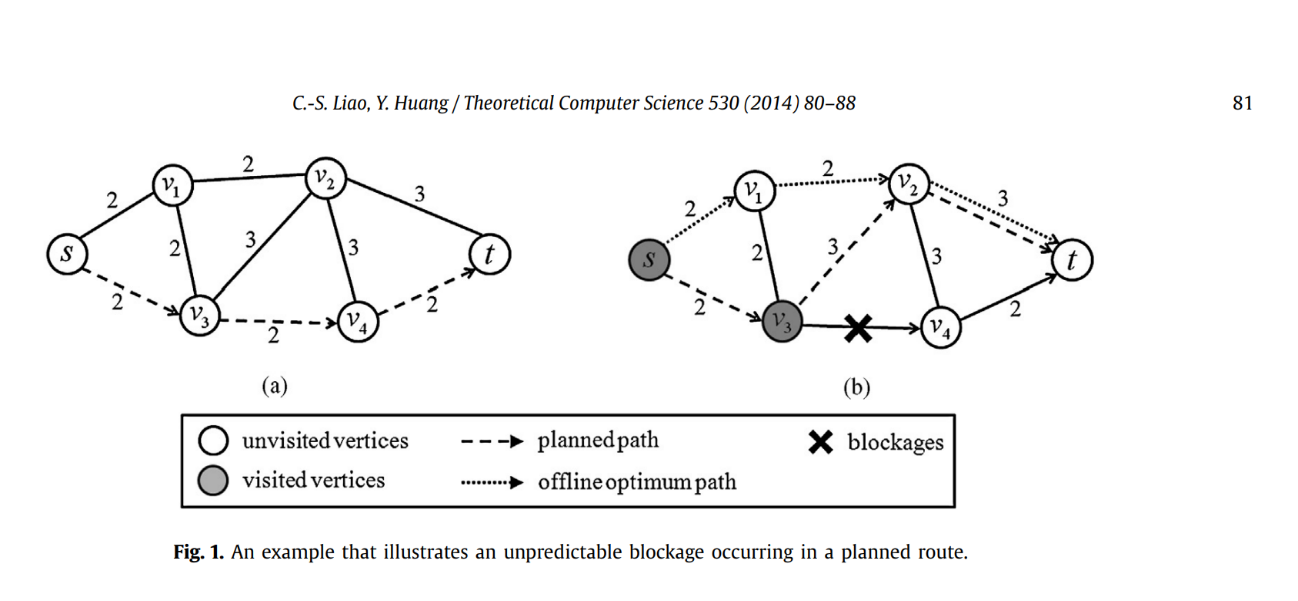
1. includes problem definition and name
2. mathematical equation of the assigned problem.
3. For each combination of parameters tested, a figure with the non-dominated final front and convergence curve of hypervolume indicator.
4. Figures where the comparison of hypervolume convergence are detailed, as well as explanation and justification of the best set of parameters tested under the perspective of balance between exploration and exploitation.
5. Same number of total numbers of fitness function evaluations should be tested in each execution (maximum value of 25.000 evaluations).

**\*Use random seed = 0.52**

Canadian Traveller Problem

Definition:

The Canadian Traveller Problem (CTP) is to find the shortest route from a source to a destination under uncertain conditions.



[*Canadian Traveller Problem example*](https://reader.elsevier.com/reader/sd/pii/S0304397514001327?token=237B006D8B72DE3EDFEF6D8B1246D35241B47C20314CAD13977E609D473B375094E99BF2F006DEF5C891618732B9EFE4&originRegion=eu-west-1&originCreation=20211208192239)

Mathematical definition:

CTP = (V, E, F, s, t, r).

exists a policy π such that for every realization (V, B) ‌‌∈ G(V, E, F),

the cost c(π, B) of the policy is no more than r times the off-line optimal, d\_B(s, t).

Complexity:

the complexity of the problem and reported it to be PSPACE-complete

Pseudocode of CPT-8:

Procedure cycle\_routing

Alpha = 1e-32; -> Division by 0 correction

    exp1 = (objetive[1] - e) \* cos(theta) - objetive[0] \* sin(theta);

    exp2 = (objetive[1] - e) \* sin(theta) + objetive[0] \* cos(theta);

    exp2 = b \* PI \* (exp2 \*\* c);

    exp2 = | sin(exp2) |;

    exp2 = a \* (exp2 \*\* d);

return (exp1 / ((exp2 - 1.0) + Alpha));

End procedure

Procedure ctp8

    theta = 0.1 \* PI;

Alpha = 1e-32; -> Division by 0 correction

    a = 40.0;

    b = 0.5;

    c = 1.0;

    d = 2.0;

    e = -2.0;

    g = 1.0 + xreal[1];

    objetive[0] = xreal[0];

    objetive[1] = g \* (1.0 – square\_root(objetive[0] / (g + Alpha)));

    constraint[0] = cycle\_routing(a, b, c, d, e, g, theta, objetive);

    theta = -0.05 \* PI; -> Second part

    a = 40.0;

    b = 2.0;

    c = 1.0;

    d = 6.0;

    e = 0.0;

    constraint[1] = cycle\_routing(a, b, c, d, e, g, theta, objetive);

end procedure

Process:

Primero se realizo una adaptacion del codigo para su compilacion en windows:

1. la adaptacion de las rutas debido a la diferencia de referenciacion de niveles dentro del sistema de archivos.
2. Ajuste las diferencias entre la version de compilacion debido a la diferencia de version de GCC, concretamente la adaptacion de LongDouble to Double, se ha considerado que no es necesaria tanta presicion para el problema concreto a tratar CTP-8, tal como se determinio en el analisis previo en la exploracion de los valores tipicos del problema.

Segundo se ha programatizado la creacion de los ficheros de parametros para el resolutor:

1. Como lenguaje se ha escogido python, para el Desarrollo de la infraestructura de investigacion.
2. Los parametros modificados y sus rangos son:

Popsize: (20-8.000) step 320  
ngen: (25-500) step 50  
pcross\_real: (0.6-1.0) step 10  
pmut\_real: (0.4-0.6) step 6  
eta\_c: (5-20) step 8  
eta\_m: (5 - 50) step 10

1. Esta eleccion ha resultado en 8320 archivos de configuracion distintos

Tercero debido a la cantiadad de posibilidades en los parametros, se ha realizado un wrapper en python para la ejecucion del resolutor:

1. Mediante el wrapper se han evaluado 3814 configuraciones distintas resultando en 89,5GB de informacion.
2. La informacion guardada en disco de cada evaluacion consta de:

all\_pop.out  
best\_pop.out  
final\_pop.out  
hyperstats.out  
hypervolume.out

1. Esta evaluacion ha tomado 1.4 dias de ejecucion, sin embargo, no se debe realizar una progresion lineal a la hora de determinar cuanto tiempo toma cada ejecucion, pues debido al orden de ficheros de parametros, los ficheros con population mayores se encuentran al final.

Cuarto ante tal cantidad de informacion se decidio utilizar la metrica de hyperstats para visualizar las diez mejores conbinaciones y las 10 diez peores siendo las siguientes:

1. Mejores evaluaciones

Hyperstat Input File

(99986271.676388, ctp8\_2487)  
(99986271.636553, ctp8\_4364)

(99986271.636425, ctp8\_4284)

(99986271.636366, ctp8\_4204)

(99986271.636211, ctp8\_4124)

(99986271.636077, ctp8\_4044)

(99986271.336364, ctp8\_2489)

(99986271.336344, ctp8\_2409)

(99986271.336331, ctp8\_2329)

(99986271.046653, ctp8\_4359)

Parameter set best evaluations:

ctp8\_2487 -> []

ctp8\_4364 -> []

ctp8\_4284 -> []

ctp8\_4204 -> []

ctp8\_4124 -> []

ctp8\_4044 -> []

ctp8\_2489 -> []

ctp8\_2409 -> []

ctp8\_2329 -> []

ctp8\_4359 -> []

1. Peores evaluaciones

Hyperstat Input File

(99985141.014467, ctp8\_10)  
(99985112.341654, ctp8\_33)  
(99985083.407344, ctp8\_37)  
(99985001.548864, ctp8\_32)  
(99984961.329343, ctp8\_38)  
(99984936.395215, ctp8\_1)

(99984914.33782, ctp8\_24)  
(99984892.410444, ctp8\_20)  
(99984749.636958, ctp8\_43)

Parameter set worse evaluations:

ctp8\_10 -> []

ctp8\_33 -> []

ctp8\_37 -> []

ctp8\_32 -> []

ctp8\_38 -> []

ctp8\_1 -> []  
ctp8\_24 -> []  
ctp8\_20 -> []  
ctp8\_43 -> []