An empirical comparison of some approximate methods for Graph Coloring

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7^{th} International Conference on Hybrid Artificial Intelligence Systems,2012

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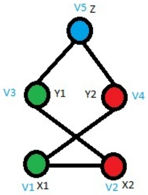
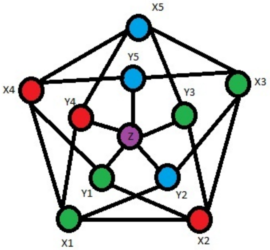
Outline

Graph Coloring Problem

- The graph coloring problem (GCP): consist in assigning a color to the vertex of a graph with the limitation that a pair of vertex that are linked cannot have the same color.





Compared Methods

- Backtracking (BT)
- DSATUR (Brèlaz) (DS)
- Simulated Annealing (SA)
- Tabu Search (TS)
- Ant Colony Optimization (ACO)
- Gravitational Swarm Intelligence (GSI)

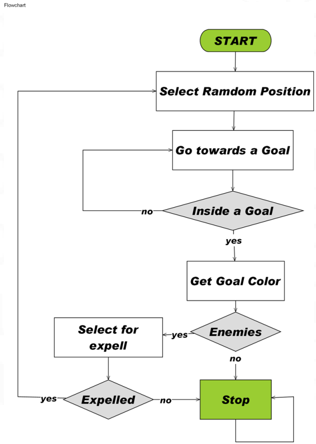
BT and DS

- BT is a greedy but exhaustive algorithm that explores all the search space and always return the optimal solution if it exists. As th GCP is NP-complete, this algorithm is useless for this problem. Only valid in small or “easy“ graphs.
- DS or Degree of saturation, developed by Brèlaz. Is also a greedy algorithm but use some techniques to search only in a particular part of the espace where the optimal solucion is in.
- DS is a big improve respect to BT, but still useless for big graphs.

SA, TS and ACO

- SA is a stochastic algorithm that moves toward the optimal solution descencing following a cooling curve. This algorithm avoids local minimun and is quite fast, depending on the slope of the cooling curve.
- TS is a local search algorithm with memory that explores the solution space keeping a trace of the best solucion found until the moment.
- ACO is a Swarm Intelligence based algorithm. Inspired in the nature, this algorithm follows the behavior of the ants. Without intelligence and wihtout a leader, the ants can complete complex tasks.

- We have implemented a Swarm Intelligence algorithm inspired in the Newtow's gravity theory.
- The agents move through the search space towards the goals (colors).



Instances

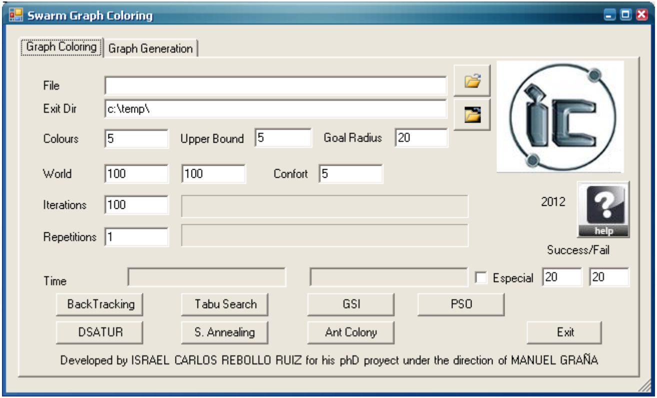
We have implemented a graph generator inspired in Kuratowsky theorem.

Graph name	#nodes	#Edges	Density	K
kuratowski 50x100 (10)	50	100	0.5	4
kuratowski 100x200 (10)	100	200	0.5	4
kuratowski 150x300 (10)	150	300	0.5	4
kuratowski 1200x400 (10)	200	400	0.5	4
kuratowski 250x500 (10)	250	500	0.5	4

The researches use the DIMACS graph coloring instances, but as we wanted to test with similar graphs we haven't use this instances, we will test with them in future work.

Experimental results.

We have implemented a Gparh Solver and a Graph Generator in MicroSoft VB.Net.



50x100 results

Each experiment have been repeated 30 times, with 5.000 step for TS, ACO and GSI, 50.000 for SA and 5.000.000 for BT and TS.

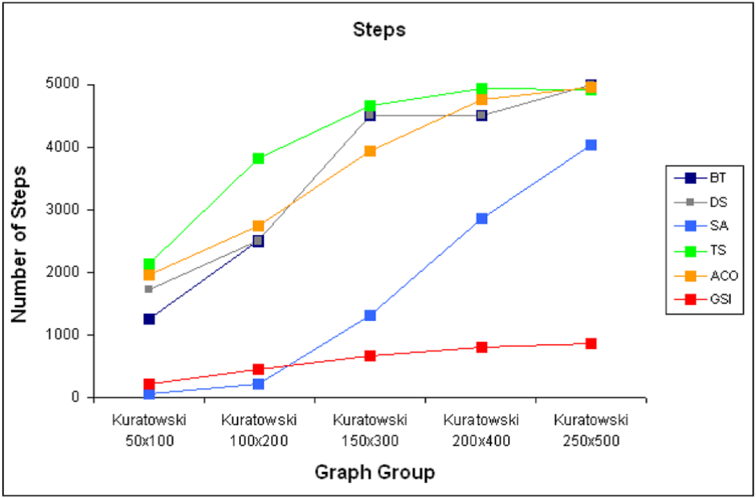
50x100	BT	DSATUR	SA	TABU	ACO	GSI
K1	100	100	100	80	73	97
K2	100	100	100	90	77	97
K3	100	0	100	47	47	100
K4	100	100	100	80	77	93
K5	100	100	100	60	70	100
K6	100	100	100	87	70	97
K7	0	0	100	67	73	93
K8	0	100	100	50	60	100
K9	100	100	100	43	57	100
K10	100	100	100	77	73	100

200x400 results

200x400	BT	DSATUR	SA	TABU	ACO	GSI
K1	0	0	20	3	30	97
K2	0	0	37	3	17	90
K3	0	0	23	0	0	93
K4	0	0	100	3	7	83
K5	0	0	87	0	23	93
K6	0	0	27	0	30	83
K7	0	0	100	0	17	90
K8	100	100	77	3	0	87
K9	0	0	57	3	7	87
K10	0	0	100	0	7	93

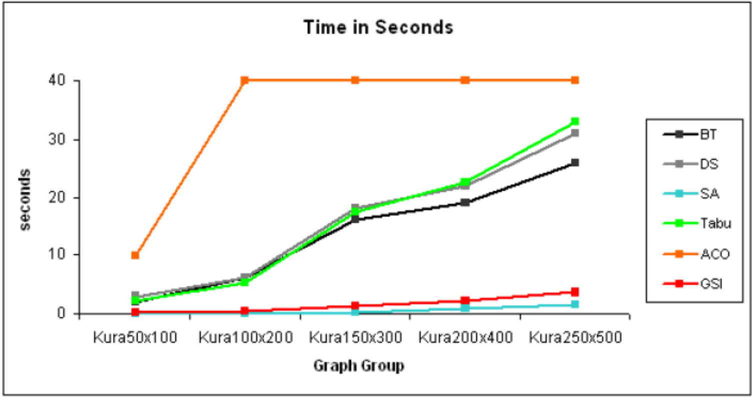
Steps

The steps of the BT, DS and SA have been normalized to 5.000



Seconds

Average time for each repetition.



Conclusions

- All the proposed methods con solve the GCP, but they depend widely on the topology of the graph.
- The SA is the best choice for small graphs, for it's speed and accuracy.
- Our GSI algorithm is good with small graphs and the best with big graphs. This approach is scalable so a parallel implementation will obtain even better resuls.
- The ACO and TS are the worst algorithms because they need too much time to obtain poor results.

Future work

- We are implementing a graph generator based on Mizuno's work, to go on testing.
- We want to add more methods for graph coloring. The Particle Swarm Optimization (PSO), will be finished soon.

The End

Thanks for your attention.

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