Overcoming Barriers by a Cluster-Moving Genetic Algorithm

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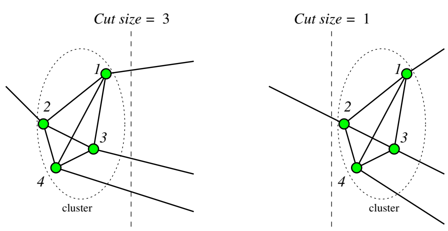
1. NEW HEURISTIC

Hybrid genetic algorithms (GAs) for the graph partitioning problem mainly use iterative improvement partitioning (IIP) algorithms for local search. Since these algorithms cannot handle *clusters* appropriately, badly located clusters play the role of barriers in space search.



(a) Before moving a cluster (b) After moving a cluster

Figure 1: An example of cluster moving

Consider the cluster shown in Figure 1(a). Moving this cluster to the opposite partition as shown in Figure 1(b) will reduce the cut size by 2. However, the cluster is hard to move by iteratively moving one vertex at a time because every vertex of the cluster has negative gain: the gains of v_1, v_2, v_3, and v_4 are -2, -4, -2, and -2, respectively. This example illustrates that IIP algorithms may miss the optimal cut that can be obtained with several times of vertex moving.

Our approach to overcome this problem is to design an additional heuristic in GA which finds clusters and moves them effectively. From local optima in population, our heuristic computes *genic distances*, characterizing the degree in which two endpoints of the edge belong to the same partition, for all the edges. As the calculation is done, the heuristic temporarily eliminates the edges of which genic distance are greater than some threshold value. After that, each connected component having more than three vertices is considered as a cluster. For each generation, some of these detected clusters with high gain values are moved. IIP local optimization is applied after cluster moving.

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2. EXPERIMENTS

We performed 100 runs for 32-way partitioning on a Pentium IV 2.8GHz computer. Table 1 shows the performance of GEFM (Genetic Extended FM algorithm) [1], one of the best performing approaches, and our Cluster-Moving Genetic Algorithm (CMGA). The results show the effectiveness of the cluster-moving heuristic in GA. On the best and the average, CMGA outperformed GEFM for most benchmark graphs in comparable time.

Table 1: Results of 32-way Partitioning

Graph	Best known	GEFM[1]			CMGA		
		Best	Ave	CPU(s)	Best	Ave	CPU(s)
G500.2.5	177	177	181.69	78.98	177	**180.82**	74.30
G500.20	4034	4037	4045.06	681.53	4035	**4042.81**	673.19
G1000.2.5	312	313	320.99	335.79	313	**320.25**	356.44
G1000.20	7818	7817	**7829.81**	2012.78	<u>7815</u>	7830.48	2363.69
U500.05	109	112	116.39	138.29	109	**113.18**	121.15
U500.40	5328	5364	5380.01	561.74	5348	**5369.83**	523.15
U1000.05	117	118	126.02	451.03	<u>115</u>	**123.49**	464.35
U1000.40	7329	7399	7417.49	1421.78	7382	**7407.18**	1493.10

The main contribution of this research is the suggestion of the heuristic that complements a major weak point of the traditional IIP algorithms (helps moving clusters). The idea of incorporating an additional operator to complement existing local optimization algorithms can also be applied to hybrid GAs for other problems.

3. ACKNOWLEDGMENTS

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4. REFERENCES

[1] Kim, J. P., and Moon, B. R. A hybrid genetic search for multi-way graph partitioning based on direct partitioning. In *Proceedings of the Genetic and Evolutionary Computation Conference* (2001), pp. 408–415.