USING CELL FORMATION FOR ESTABLISHING THE GROUPS OF SUB-FLOW TREES IN REDUCING SINGLE FLOW ACCUMULATION PROBLEM

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ABSTRACT

In reducing single flow accumulation problem, the flow trees are split and after that combined into new flow trees to establish new sub-flow trees without exceed the given accumulation threshold values. Grouping tree process is the combination of subtrees. In generally, beside the accumulation values, (sub-)tree groups could be satisfied some critical constrains such as: temporal, the limit number of partitions, ... This paper presents a method using CFP (cell formation problem) to solve the grouping flow trees in single flow accumulation model.

1. INTRODUCTION

Graph partitioning is a problem having many researches. Recently, in 2015, Menouar Boulif presented a work of using cell formation for graph partitioning. Single flow accumulation by O'Callaghan and Mark has been being interested in many researchs since nearly 40 years. In recent years, single flow accumulation is present by graph-based method and in research for avoid over-accumulation-threshold flows Truly, a forest graph is used to modeling flow. Flow accumulation is determined by tree graph algorithms. From then, over-threshold trees wil be recognized and be offered handling. Finding joining trees and tree partitioning on their branches is one of the group of methods. In case, a forest has only one tree having over-threshold flow accumulation, joining and partitioning activities may not affected to other trees globally. Then, in this case, the optimization tends to the local factors, such as: the number of changing locations. But, if forest have a lot of over-threshold trees or large accumulated tree having its neighbor set of supporting-decreasing-flow trees, then choosing group of trees to support each over-threshold trees is more complexity problem.

Of course, the flow accumulation graph model is a directed tree-like graph and its properties. This paper proposes using method for cell formation problem to partition the graph-based flow for over-threshold flow problem.

2. METHODOLOGY

2.1 Graph-based flow accumulation modelling

2.1.1 *Graph-based for single flow accumulation description*

Anthony et al (2014) have used graph to illustrated single flow accumulation. The main purpose of that research aimed to managing multi-scale watershed delineation. The graph composed by set of vertices and edges. Vertices are the locations on the DEM, the center of each cells/nodes in DEM. Edges are the connections of vertices, that's mean the flows between nodes. For single flow accumulation, graph are directed trees, so called forest (graph).

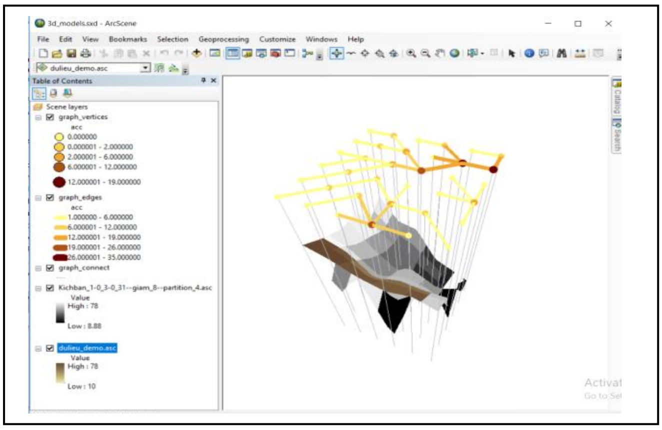

Figure 1. An illustration of graph-based flow accumulation represent.

2.1.2 *Over-threshold problem on graph-based for single flow accumulation*

Threshold is a real number value to comapare with flow accumulation. By definition, if one flow has accumulated greater than threshold then that flow is called over-threshold flow. Finding sub-flow that accumulation is greater than threshold is not a big problem. Graph-based method easily manages set of over-threshold flows (in tree type). In theory, to solve the problem, we can adjust the elevation to create the new flow in somewhere of elevation to archiving appropriate flow system. The raising problem is choosing the set of locations to change the elevation. Because the changing elevation could lead to affect many other flows. So, the computing combination will be faced when trying many scripts of changing values in elevation.

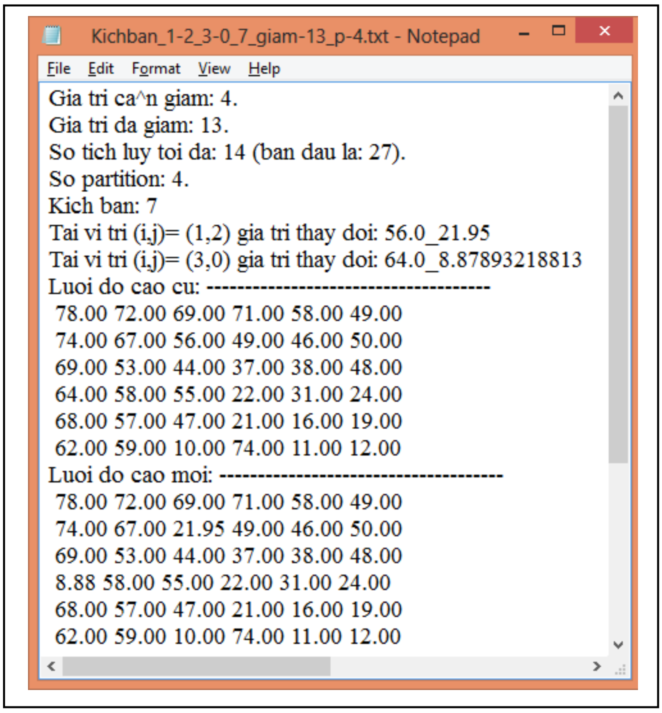

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Figure 2. One script of changing elevation in DEM.

In the period 2014 – 2017, we have developed method for solve the tree flow over threshold. The proposed algorithm is take care of points on boundaries of flows and branches partitioning points. Because the change in these points could change two flows in that boundary. This strategy could reduce because the method does not try all points in space. Due to the speed in calculation is increase. The smarter options in choosing set of changing elevation are prioritizing points beginner of tree branches.

But all optimization methods in choosing set of changing elevation points are locally. Because the forest graph may exist many over-threshold trees.

2.2 Cell formation (CF) problem in brief

According to the research of Iraj Mahdavi et al (2009), cell formation problem (CFP) belongs to cellular manufacturing, an industrial application of group technology concept. Grouping “machines” and “parts” in “dedicated manufacturing cells” and avoiding exceptional elements in cells are focusing actions of CFP. Mathematical model of pure cell formation problem is described in Mahdavi et al (2009) as below.

Indexing sets:

- i: index for “parts”, $i = 1..P$.
- j: index for “machines” $j = 1..M$.
- k: index for cells $k = 1..C$.

Relationship between “parts” and “machines”

● Matrix r: r_{ij} has value either 1 or 0: 1 if part i to be “processed” on “machine” j, 0: otherwise.

● Cell utilization: the number of non-zero elements of block-diagonal divided by the block-diagonal matrix size of each cell. This value must be minimized (Min_ut_k).

Decision variables and constraints:

● Binary matrix jxk Y: Y_{jk}: 1 if “machine” j is assigned to cell k, 0 otherwise. Lead to constraints: sum of Y_{jk} on j equals to 1 (for all k).

● Binary matrix ixk Z: Z_{ik}: 1: if “part” i is assigned to cell k, 0 otherwise. Lead to constraints: sum of Z_{ik} on i equals to 1 (for all k).

Then, finally, the optimization is:

$$\sum_{i=1}^{P}\sum_{j=1}^{M} Z_{ik}Y_{jk}r_{ij} \geq Min\_ut_k \times \sum_{i=1}^{P}\sum_{j=1}^{M} Z_{ik}Y_{jk}, \forall k$$

$$Z_{ik}, Y_{jk} \in \{0,1\}, \forall i, j, k$$

To solve cell formation problem, from 1984 to now, there are many (over 7) algorithms which are non-heuristic and heuristics solutions.The method Mahdavi et al (2009) proposed must implement six components (of an genetic algorithm):

● The scheme for coding
● The initial population
● An adaption function
● Selection procedure

● The genetic operators
● Control parameter values (for control in genetic algorithm)

	P2	P4	P6	P1	P3	P5	
M1	1	1	1				Cellular 1 (nhóm 1)
M2	1	1	1				Cellular 2 (nhóm 2)
M3				1	1	1	
M4				1	1	1	

Figure 3. Illustration on grouping "machines" and "parts" into k=2 group.

Table 1. Seven algorithms for CF problem.

Algorithms	Year	Authors
ZODIAC	1987	Chandrasekharan and Rajagopalan
GRAFICS	1991	Srinivasan and Narendran
GATSP-Genetic algorithm	1998	Cheng et al
GA – Genetic algorithm	2001	Onwubolu và Mutingi
EA – evolutionary algorithm	2004	Goncalves và Resende
SA – simulated annealing	2008	Wu et al
GA	2009	Iraj Mahdavi et al

3. PROPOSED ALGORITHM

3.1 Problem detection

Set of over-threshold trees or their branches as well as their neighbors play a role of elements in cell formation problem. The solution is the way partitioning the group of location to form new flow. Each group must ensure the first condition on threshold value. To do this, at least, the following steps must be done:

● Locating over-threshold trees.
● Searching additional over-threshold branches of trees.
● Building the cell formation inputs.
● Executing the selected CF algorithm.

Main challenge for applying cell formation in flow accumulation problem is the flow dependencies. In fact, an branch belongs to a group then that dependent-flow branches may be (or in some cases must be) in the same group. Therefore, the tree branches elements are not absolutely independent.

3.2 Mathematical model

As analyzing in previous section, the mathematics model for cell formation in flow accumulation must append the relationship for relation trees/branches. In mathematically, we should supply some additional equations to describing the same group of dependently "part".

For example: $\mathrm{b_0}$ is the center branch/tree and $\mathrm{b_{left}}$ and $\mathrm{b_{right}}$ is two branch/tree in different group. Set of $\{\mathrm{b_{-1}}, \mathrm{b_{-2}}, \ldots\}$ are on the leftside of $\mathrm{b_0}$ but they are on the rightside of $\mathrm{b_{left}}$. Similarly, set of $\{\mathrm{b_1}, \mathrm{b_2}, \ldots\}$ on the rightside of $\mathrm{b_0}$ but on the leftside of $\mathrm{b_{right}}$. So the group must be declare such as:

$$b_{left} \leq \cdots \leq b_{-2} \leq b_{-1} \leq b_0 \leq b_1 \leq b_2 \leq \cdots \leq b_{right}$$
$$b_{left} < b_{right} \; or \; b_{left} <> b_{right}$$

This constraint will be added into the cell formation problem model. In this case, b_0 is called the "center" of branches.

3.3 Proposed algorithm

In programming, the above constraints may be added by detecting ancestors (called "ancestor rule") of one branch in the flow graph. For graph-base software packages, we easily checking two branches ancestor relation just by checking two node in each branch. By preprocessing, we could choice the value of "center" to make the set of scripts.

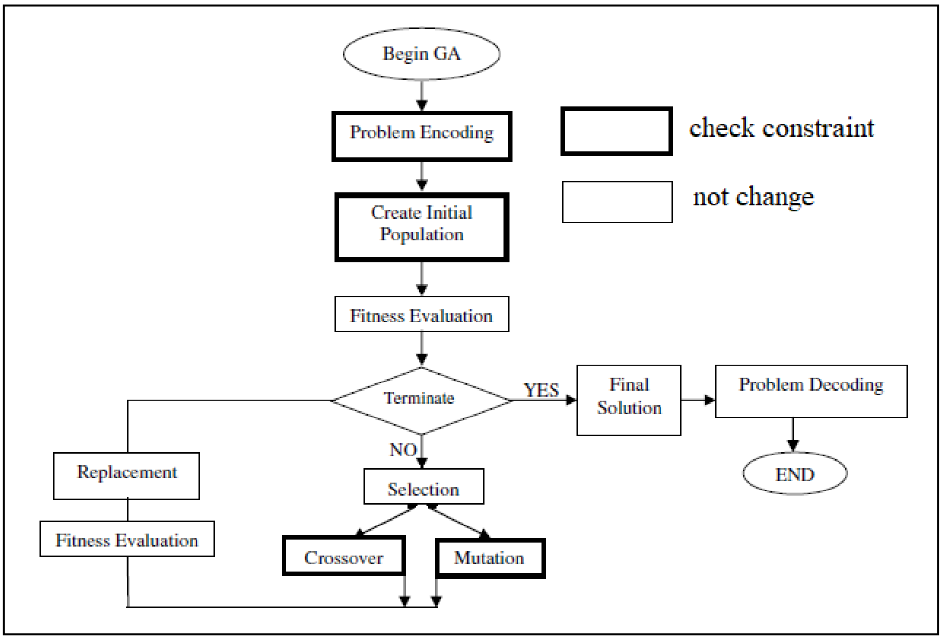

Figure 4. Checking for the ancestor rule specs.

Back in GA of Mahdivi (2009) proposed, the chromosome is a string indicating the "parts" and the "machines". So the following functions will affected by the mathematical constraints:

- Initial population function.

- Crossover operator (includes: Simple crossover, Uniform crossover).
- Mutation operator.

Other functions are not involved with this constraint:
- Fitness function.
- Selection rule.
- Parameters.

4. CONCLUSION

When modelled accumulation flow problem by graph, not only flow element such as flow boundaries have been easily managed, but also controlling flow is enabled. And this paper proposes solving cell formation problem in order to partitioning the flow into group. To facing the flow attributes, the proposed algorithm is edited from pure cell formation problem. In this proposed algorithm, we focus on the functions must change to adapt the constraint of flow with having spatial graph-base feature.

5. REFERENCES

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