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Improving Computing Performance for Algorithm Finding Maximal Flows on Extended Mixed Networks

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Abstract. Graph is a powerful mathematical tool applied in many fields as transportation, communication, informatics, economy, … In ordinary graph the weights of edges and vertexes are considered independently where the length of a path is the sum of weights of the edges and the vertexes on this path. However, in many practical problems, weights at a vertex are not the same for all paths passing this vertex, but depend on coming and leaving edges. The paper develops a model of extended network that can be applied to modelling many practical problems more exactly and effectively. The main contribution of this paper is a source-sink alternative algorithm, then improving computing performance for algorithm finding maximal flows on extended mixed networks.

Keywords: extended, graph, network, flow, maximal flow, algorithm.

1. Introduction

Graph is a powerful mathematical tool applied in many fields as transportation, communication, informatics, economy, … In ordinary graph the weights of edges and vertexes are considered independently where the length of a path is simply the sum of weights of the edges and the vertexes on this path. However, in many practical problems, weights at a vertex are not the same for all paths passing this vertex, but depend on coming and leaving edges. Therefore, a more general type of weighted graphs, called extended weighted graph, is defined in this work. The paper develops a model of extended network that can be applied to modelling many practical problems more exactly and effectively. Therefore, necessary to build a model of the extended network so that the stylization of practical problems can be applied more accurately and effectively. Based on the results of the study of the problem regarding finding the maximum flow [1], [2] and extended graphs [3], the main contribution of this paper is the revised Ford-Fulkerson algorithm finding maximal flows on extended mixed networks and improving computing performance.

2. Extended Mixed Network

A network is a mixed graph of the traffic $G = (V, E)$, circles V and roads E. Roads can be classified as either direction or non-direction. There are many sorts of means of transportation on the network. The non-direction shows two-way roads while the direction shows one-way roads. Given a group of the functions on the network as follows:

+The function of the route circulation possibility $c_E: \mathrm{E} \to \mathrm{R}^*$, $c_E(e)$ the route circulation possibility $e \in \mathrm{E}$.

+The function of the circle circulation possibility $c_V: \mathrm{V} \to \mathrm{R}^*$, $c_V(u)$ the circle circulation possibility $u \in \mathrm{V}$.

+$G = (V, E, c_E, c_V)$: extended mixed network.

3. Flow of The Extended Mixed Network

Given an extended mixed network $G = (V, E, c_E, c_V)$, a source point a and a sink point z.
Set: $\{f(x,y) \mid (x,y)\in G\}$, is called the flow of network G if the requirements are met:

(i) $0 \le f(x,y) \le c_E(x,y) \ \forall(x,y)\in G$

(ii) Any value of point r is referring to neither a sourse point nor a sink point

$$\sum_{(v,r)\in G} f(v,r) = \sum_{(r,v)\in G} f(r,v)$$

(iii) Any value of point r is referring to neither a sourse point nor a sink point

$$\sum_{(v,r)\in G} f(v,r) \le c_V(r)$$

Expression: $v(\mathrm{F}) = \sum_{(a,v)\in G} f(a,v)$, is called the value of flow F.

• ***The maximum problem:***

Given an extended mixed network $G = (V, E, c_E, c_V)$, a source point a and a sink point z. The task required by the problem is finding the flow which has a maximum value. The flow value is limited by the total amount of the circulation possibility on the roads starting from source points. As a result of this, there could be a confirmation on the following theorem.

• *Theorem 1:* Given an extended mixed network $G = (V, E, c_E, c_V)$, a source point a and a sink point z, then exist is the maximal flow [1].

4. Source-Sink Alternative Algorithm Finding Maximal Flows on Extended Mixed Networks [2]

+ ***Input:*** Given an extended mixed network $G = (V, E, c_E, c_V)$, a source point a and a sink point z. The points in graph G are arranged in a certain order.
+ ***Output:*** Maximal flow $F = \{f(x,y) \mid (x,y)\in G\}$.

(1) Start:

The departure flow: $f(x,y) := 0, \forall(x,y)\in G$.
Points from the source points and sink points will gradually be labelled L_1 for the first time including 5 components.

Form forward label:

$L_1(v) = [\uparrow, prev_1(v), c_1(v), d_1(v), bit_1(v)]$ and can be label $(\uparrow)$ for the second time

$L_2(v) = [\uparrow, prev_2(v), c_2(v), d_2(v), bit_2(v)]$,

Form backward label:

$L_1(v) = [\downarrow, prev_1(v), c_1(v), d_1(v), bit_1(v)]$ and can be label $(\downarrow)$ for the second time

$L_2(v) = [\downarrow, prev_2(v), c_2(v), d_2(v), bit_2(v)]$,

Put labeling $(\uparrow)$ for source point and labeling $(\downarrow)$ for sink point:

$$a[\uparrow, \phi, \infty, \infty, 1] \ \& \ z[\downarrow, \phi, \infty, \infty, 1]$$

The set S comprises the points which have already been labelled $(\uparrow)$ but are not used to label $(\uparrow)$, S' is the point set labelled $(\uparrow)$ based on the points of the set S. Begin $S := \{a\}, S' := \phi$

The set T comprises the points which have already been labelled $(\downarrow)$ but are not used to label $(\downarrow)$, T' is the point set labelled $(\downarrow)$ based on the points of the set T. Begin $T := \{z\}, T' := \phi$

(2) Forward label generate:

(2.1) Choose forward label point:

• Case $S \neq \varnothing$: Choose the point $u \in S$ of a minimum value. Remove the u from the set S, $S := S \setminus \{ u \}$.

Assuming that the forward label of u is $[\uparrow, prev_i(u), c_i(v), d_i(v), bit_i(v)]$, i = 1 or 2. A is the set of the points which are not forward label time and adjacent to the forward label point u. Step (2.2).

• Case $S = \varnothing$ and $S' \neq \varnothing$: Assign $S := S'$, $S' := \varnothing$. ***Step (3)***.