

Core Maintenance

This repository contains C++ codes and datasets for the paper.

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Introduction

We present efficient algorithms for maintaining (α, β) -core (bi-core) over bipartite graphs. Our approach introduces the concept of bi-core numbers and uses them to narrow down the scope of updates caused by edge insertions and deletions. Based on this concept, we propose efficient algorithms for maintaining (α, β) -core, for both edge insertion and edge deletion.

Environment

The algorithms are implemented in C++ and compiled with the g++ compiler at -O3 optimization level. The development environment used for implementing and testing is:

- Linux version: Ubuntu 20.04.3 LTS
- Kernel version: 5.4.0-139-generic
- g++ version: 9.4.0

Datasets

We use eight large bipartite graphs, including seven real graphs (IMDB, WC, AR, DBLP, DE, DTI, WT) obtained from [KONECT](#) and one synthetic graph (PL) generated according to the bipartite network model[6], following the power-law distribution. You can generate PL by running the following command in the terminal:

```
1) cd random
2) g++ bigraph.cpp gephi.cpp main.cpp random.cpp utility.cpp -O3 -o rand.o
3) ./rand.o output_location 5000000 5000000 1000000000
```

Our paper contains the detailed statistics and original sources of the above datasets.

Dataset format:

- `graph.meta` file containing the number of vertices on each side and the number of edges.
- `graph.e` file containing all the edges.

Example:

```
graph.meta:
3 //number of vertices in U-side
3 //number of vertices in V-side
6 //number of edges

graph.e:
//U V
1 1
1 3
2 1
2 2
2 3
3 1
```

How to Run the Codes

A. Code Compilation

Both the `insertion-maintenance` and `deletion-maintenance` folders contain a `Makefile`. To compile the corresponding code:

```
1) cd insertion-maintenance/ or cd deletion-maintenance/
2) make
```

After compilation, an executable file named `bicore` will be generated.

B. Experimentation

1. Algorithms

- Recompute: the state-of-the-art bi-core decomposition algorithm.
- BiCore-Index-Ins* (BII): the bi-core maintenance algorithm to handle an edge insertion [26].
- BiCore-Index-Rem* (BIR): the bi-core maintenance algorithm to handle an edge deletion [26].
- Edge-Insert (EI): our proposed bi-core maintenance algorithm for handling an edge insertion.
- Edge-Delete (ED): our proposed bi-core maintenance algorithm for handling an edge deletion.
- BI-batch: the batch algorithm in [26].
- Edge-batch: our batch algorithm.

Parameter	Description
<code>graph_path</code>	The path of the graph.
<code>vertex_1/vertex_2</code>	(vertex_1, vertex_2) is the inserted or deleted edge.
<code>insert_path/delete_path</code>	The inserted/deleted edges list file.
<code>edge_num</code>	The total number of inserted and deleted edges.
<code>U_num/V_num</code>	The number of left/right side vertices in the graph.
α/β	(α, β) is the given integer pair.
<code>vertex</code>	The given vertex.
<code>is_left</code>	Indicates whether the given vertex belongs to U or V. 1 (True) for U, 0 (False) for V.

2. Preparation

Parameter of Command Line	Description	Command
<code>BBI</code>	Build BiCore-Index	<code>sh BBI.sh graph_path</code>
<code>BBN</code>	Compute all bi-core numbers	<code>sh BBN.sh graph_path</code>

3. Edge Insertions

3.1 Insert a specific edge (u_1, v_1)

Parameter of Command Line	Description	Command
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Parameter of Command Line	Description	Command
RCI	Recompute	sh RCI.sh graph_path vertex_1 vertex_2
BII	BiCore-Index-Ins* (BII)	sh BII.sh graph_path vertex_1 vertex_2
EI	Edge-Insert (EI)	sh EI.sh graph_path vertex_1 vertex_2

3.2 Insert edges from an edge list file

Parameter of Command Line	Description	Command
RCIS	Recompute	sh RCIS.sh graph_path insert_path
BIIS	BiCore-Index-Ins* (BII)	sh BIIS.sh graph_path insert_path
EIS	Edge-Insert (EI)	sh EIS.sh graph_path insert_path

4. Edge Deletion

4.1 Delete a specific edge (u_1, v_1)

Parameter of Command Line	Description	Command
RCR	Recompute	sh RCR.sh graph_path vertex_1 vertex_2
BIR	BiCore-Index-Rem* (BIR)	sh BIR.sh graph_path vertex_1 vertex_2
ED	Edge-Delete (ED)	sh ED.sh graph_path vertex_1 vertex_2

4.2 Delete edges from an edge list file.

Parameter of Command Line	Description	Command
RCRS	Recompute	sh RCRS.sh graph_path delete_path
BIRS	BiCore-Index-Rem* (BIR)	sh BIRS.sh graph_path delete_path
EDS	Edge-Delete (ED)	sh EDS.sh graph_path delete_path

5. Batch Update

Parameter of Command Line	Description	Command
BBatch	BII-batch	sh BBatch.sh graph_path edge_num U_num V_num
EBatch	EI-batch	sh EBatch.sh graph_path edge_num U_num V_num

6. Query

6.1 (α, β) -core query:

Parameter of Command Line	Description	Command
QCBI	BiCore-Index	sh QCBI.sh graph_path α β
QCBN	BiCore number	sh QCBN.sh graph_path α β

6.2 community search:

Parameter of Command Line	Description	Command
QSBI	BiCore-Index	sh QSBI.sh graph_path α β vertex is_left
QSNB	BiCore number	sh QSNB.sh graph_path α β vertex is_left

6.3 α/β -offsets query:

Parameter of Command Line	Description	Command
QOBI	BiCore-Index	sh QOBI.sh graph_path vertex is_left
QOBN	BiCore number	sh QOBN.sh graph_path vertex is_left

Running Example

1. Toy Graph

- Number of vertices: 6, number of edges: 6
- Edge list:
 - u_1-v_1
 - u_1-v_3
 - u_2-v_1
 - u_2-v_2
 - u_2-v_3
 - u_3-v_1
- We can obtain the original bi-core numbers of all vertices:

U	V
$u_1: (1, 3), (2, 2)$	$v_1: (1, 3), (2, 2), (3, 1)$
$u_2: (1, 3), (2, 2), (3, 1)$	$v_2: (3, 1)$
$u_3: (1, 3)$	$v_3: (2, 2), (3, 1)$

2. Edge Insertion

Suppose we want to insert edge (u_1, v_2) , we can run:

```
sh EI.sh ../data/example/ 1 2
```

The updated bi-core number of all vertices are stored in "bi-core number". The content is listed as follows:

U	V
$u_1: (1, 3), (3, 2)$	$v_1: (1, 3), (3, 2)$
$u_2: (1, 3), (3, 2)$	$v_2: (3, 2)$
$u_3: (1, 3)$	$v_3: (3, 2)$

3. Edge Deletion

Suppose we want to delete edge (u_1, v_2) after the edge insertion, we can run:

```
sh ER.sh ../data/example_AfterIn/ 1 2
```

The updated bi-core number of all vertices are stored in "bi-core number". The content is listed as follows:

U	V
$u_1: (1, 3), (2, 2)$	$v_1: (1, 3), (2, 2), (3, 1)$
$u_2: (1, 3), (2, 2), (3, 1)$	$v_2: (3, 1)$
$u_3: (1, 3)$	$v_3: (2, 2), (3, 1)$