

Clustering of dynamic graphs

Hauptseminar Networkvisualisation

Moritz Hamann



Abb. 1. In den Wolken: Vancouver von Cypress Mountain. Auf der ersten Seite dürfen keine Grafiken außer dieser optionalen Aufmachgrafik (Teaser) abgebildet sein.

Kurzbeschreibung—This paper presents a summary about various techniques to detect and identify densely connected nodes in a graph, so called clusters. In the first part, we introduce the concept of clusters for static graphs alongside their main properties. For dynamic graphs with time varying edge connections, these cluster may be subject to change with every time step. Therefore additional characteristics have to be introduced.

The second part describes two methods to detect, identify and track cluster in a dynamic graph. A common solution for this problem is the clustering of a static graph at each time step, and the identification of the same clusters over multiple time steps. A method is presented to track these clusters, which is independent of the underlying static graph clustering algorithm. Furthermore, we describe an extension of the k-clique percolation algorithm to dynamic graphs.

Finally, the clique percolation algorithm is applied to two different real world networks, which yields interesting result about group dynamics, with regards to the correlation of various group properties.

1 MOTIVATION

in letzten jahren vermehrte forschung im bereich graphen. einerseits wegen zunahme an netzwerken in vernetzter welt, andererseits weil graphen viele probleme abbilden koennen. dazu gehoeren computer science, control science, kommunikation und social networks. vor allem wegen social networks und daraus social marketing sind dynamic graphs mehr ins licht gerueckt. dynamische graphen sind graphen mit varierenden kanten. hierbei spielt vor allem die kommunikation, und die daraus entstehenden untergruppen des netzwerks (cluster) eine grosse rolle. man mochte herausfinden wie sich solche gruppen finden lassen, wie sie das netzwerk beeinflussen, und sich im verlauf der zeit entwickeln.

2 BASICS

was sind cluster, ueberlappende cluster, definition?

2.1 Properties of Cluster

2.2 Properties of dynamic graphs

3 CLUSTERING IN STATIC GRAPHS

3.1 Clique percolation

3.2 modularity function clustering?

4 CLUSTERING IN DYNAMIC GRAPHS

4.1 Extension of clique percolation

4.2 Time step Clustering

5 MAYBE VISUALIZATION OF DYNAMIC GRAPHS

6 GROUP EVOLUTION (RESULTS)

7 CONCLUSION

7.1 Abbildungen und Tabellen

Alle Abbildungen (siehe Abb. 2) und Tabellen (Tabelle 1) sollten zentriert sein (`\centering`). Abbildungen über beide Textspalten (Abb. 3) können mit `\begin{figure*}...\end{figure*}` eingefügt werden.

7.2 Referenzen

Literaturangaben wie beispielsweise Levoy [4] werden mit Hilfe von BibTeX erzeugt. Dazu werden die Referenzen in die Literaturliste

(hier *literatur.bib*) eingetragen und entsprechend mit `\cite` referenziert.

7.3 L^AT_EX-Übersetzung

Die L^AT_EX-Datei kann mit *latex* oder *pdflatex* übersetzt werden. Dabei ist zu beachten, dass für die Übersetzung mit *latex* die Grafiken in Postscript (eps) vorliegen, für *pdflatex* entsprechend als jpg, png oder pdf. Der Ablauf ist dabei der folgende:

1. `pdflatex <quelldatei.tex>`
2. `bibtex <quelldatei>`
3. `pdflatex <quelldatei.tex>` (evtl. mehrfach)

Alternativ kann auch das mitgelieferte Makefile verwendet werden.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua [3, 6]. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi [1]. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua.

Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum [9]. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua [2].

Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat [4]. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam

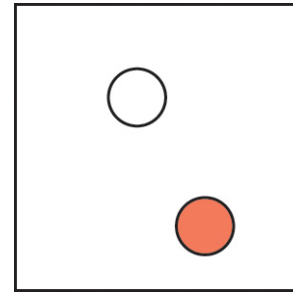


Abb. 2. Beispielillustration.

erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua.

$$\sum_{j=1}^z j = \frac{z(z+1)}{2} \quad (1)$$

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et

Tabelle 1. Vis Paper Acceptance Rate

| Year | Submitted | Accepted | Accepted (%) |
|------|-----------|----------|--------------|
| 1994 | 91 | 41 | 45.1 |
| 1995 | 102 | 41 | 40.2 |
| 1996 | 101 | 43 | 42.6 |
| 1997 | 117 | 44 | 37.6 |
| 1998 | 118 | 50 | 42.4 |
| 1999 | 129 | 47 | 36.4 |
| 2000 | 151 | 52 | 34.4 |
| 2001 | 152 | 51 | 33.6 |
| 2002 | 172 | 58 | 33.7 |
| 2003 | 192 | 63 | 32.8 |
| 2004 | 167 | 46 | 27.6 |
| 2005 | 268 | 88 | 32.8 |
| 2006 | 228 | 63 | 27.6 |

dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

7.4 Mezcal Head

Duis autem [5] vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi. Lorem ipsum dolor sit amet, consetetur adipiscing elit, sed diam nonumy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat¹.

7.4.1 Ejector Seat Reservation

Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat [7]. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi.

¹Fußnoten erscheinen an der Unterkante der Spalte. Sie sollten jedoch vermieden werden, da der Lesefluss gestört wird.

Rejected Ejector Seat Reservation Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie

8 CONCLUSION

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum.

LITERATUR

- [1] G. Grinstein, D. Keim, and M. Ward. Information visualization, visual data mining, and its application to drug design. IEEE Visualization 2002 Course #1 Notes, October 2002.
- [2] G. Kindlmann. Semi-automatic generation of transfer functions for direct volume rendering. Master's thesis, Cornell University, 1999.
- [3] Kitware, Inc. *The Visualization Toolkit User's Guide*, January 2003.
- [4] M. Levoy. *Display of Surfaces from Volume Data*. PhD thesis, University of North Carolina at Chapel Hill, 1989.
- [5] W. E. Lorensen and H. E. Cline. Marching cubes: A high resolution 3d surface construction algorithm. In *Computer Graphics (Proceedings of SIGGRAPH 87)*, volume 21, pages 163–169, July 1987.
- [6] N. Max. Optical models for direct volume rendering. *IEEE Transactions on Visualization and Computer Graphics*, 1(2):99–108, June 1995.
- [7] G. M. Nielson and B. Hamann. The asymptotic decider: Removing the ambiguity in marching cubes. In *Visualization '91*, pages 83–91, 1991.
- [8] M. Strengert, T. Klein, R. Botchen, S. Stegmaier, M. Chen, and T. Ertl. Spectral volume rendering using GPU-based raycasting. *The Visual Computer*, 22(8):550–561, 2006.
- [9] C. Ware. *Information Visualization: Perception for Design*. Morgan Kaufmann Publishers, second edition, 2004.

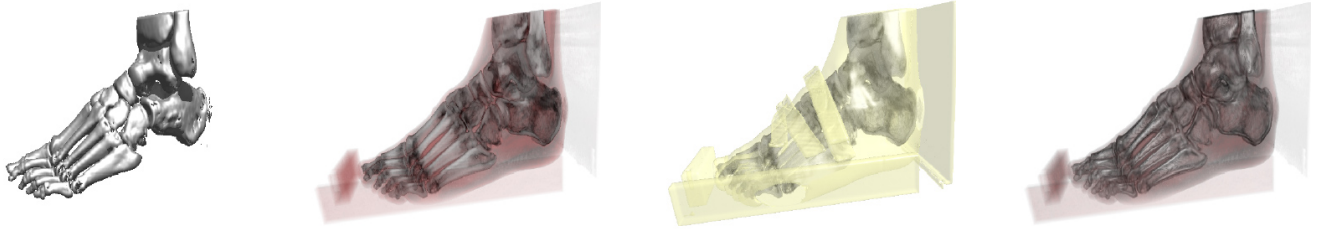


Abb. 3. Illustration über beide Textspalten hinweg. Auch Illustrationen müssen entsprechend den Quellen gekennzeichnet werden. [8]