Using Camera State Transforms for Commuter Network Visualization

Yves Chiricota[1]
Michael J. McGuffin[2]
Martin Simard[1]

1. Université du Québec à Chicoutimi, Chicoutimi, Canada
2. École de technologie supérieure, Montreal, Canada

UNIVERSITÉ DU QUÉBEC À CHICOUTIMI

Le génie pour l'industrie

This work is supported by CRSNG NSERC

I. Original problem

II. Metric-based mapping and filtering

III. Camera state mapping

I. Original problem

Gain insight into a commuter network in France

Data from INSEE covering several years: 1975, 1980, 1995, 1999

~32 000 cities and ~3 000 000 links

Objectives:

Allow geographers to explore migration data.

Locate the largest and smallest flows.

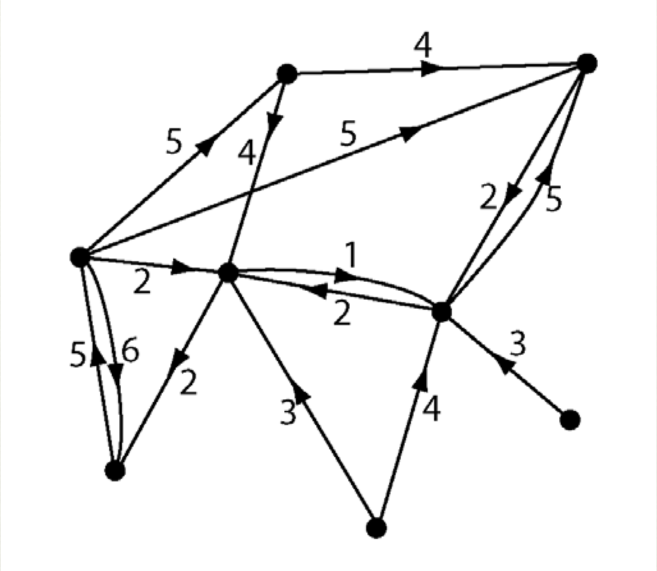
Examine movements.

Compare flows.

Locate origin/destination.

Our approach:

Commuter network <-> Weighted graph

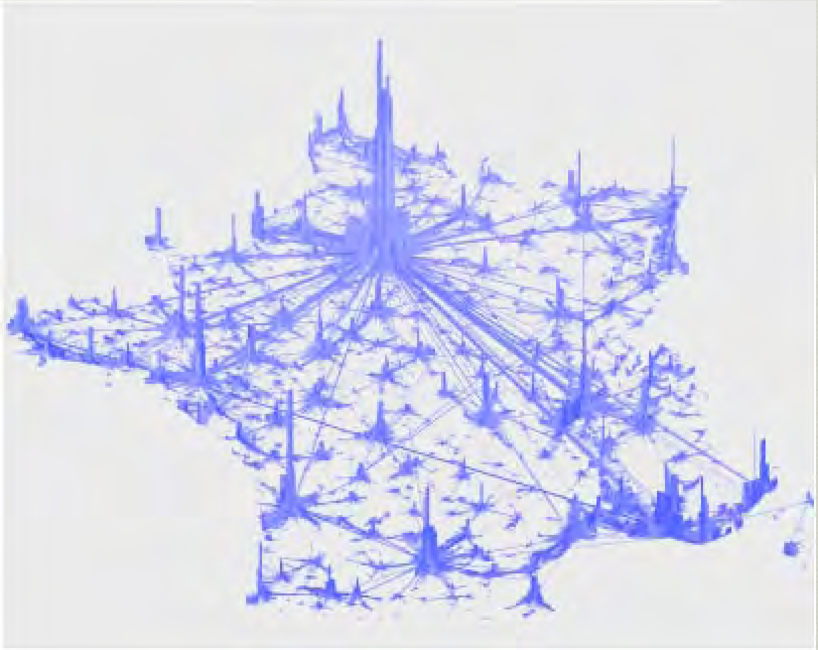


2D/3D visualization + metric filtering.

We use 3D

3D provides more room to show information.

Humans are able to very quickly interpret depth cues, shading, perspective, etc.



3D is convenient for navigation.

II. Metric-based mapping and filtering

Well-known method to simplify visualization of a graph $G = (V, E)$.

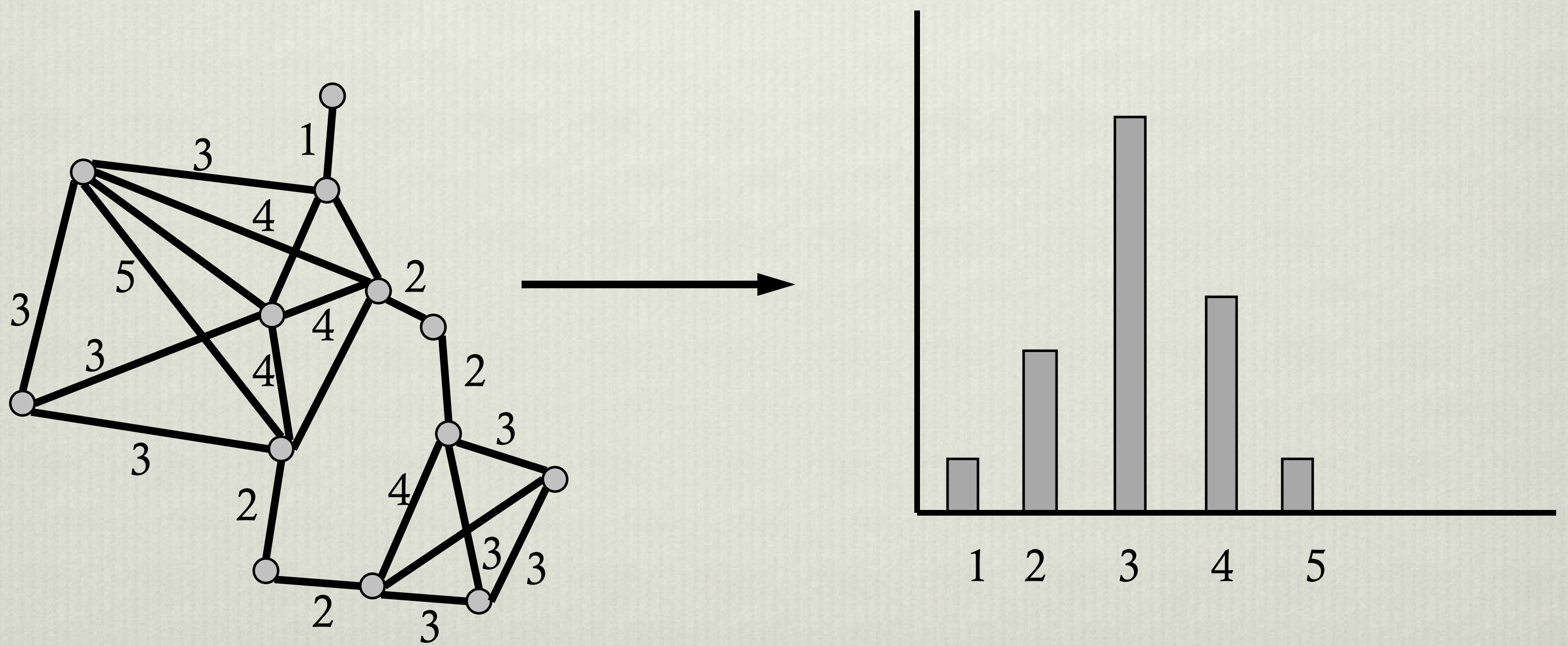
Metric~Weight~Mapping $f : V \text{ (or } E) \longrightarrow \boldsymbol{R}$

Metric filtering consists of displaying only elements whose weight falls within a certain range (for example, between two specific values).

Metric-based filtering

Provides a convenient way to achieve graph simplification.

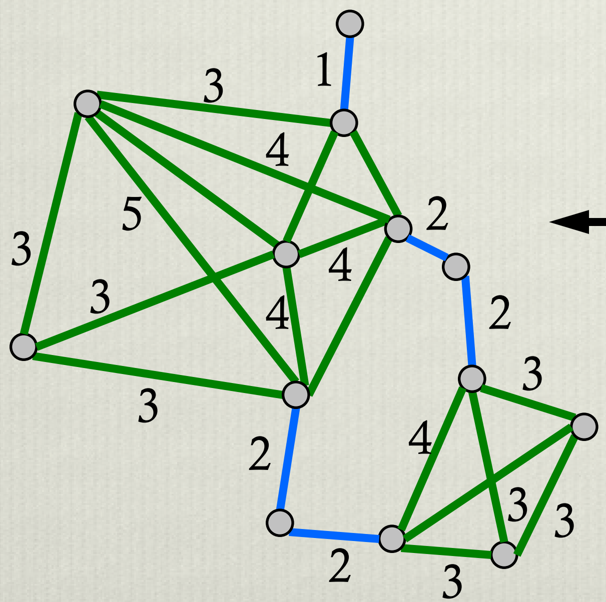
Low-pass filtering : remove from G edges e such that $\Sigma(e) < \tau$.

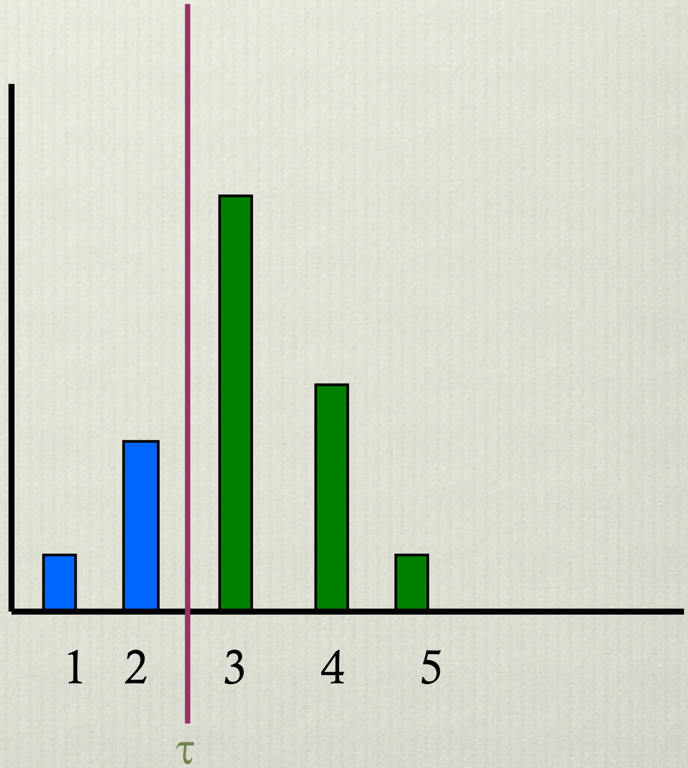


Metric-based filtering

Provides a convenient way to achieve graph simplification.

Low-pass filtering : remove from G edges e such that $\Sigma(e) < \tau$.

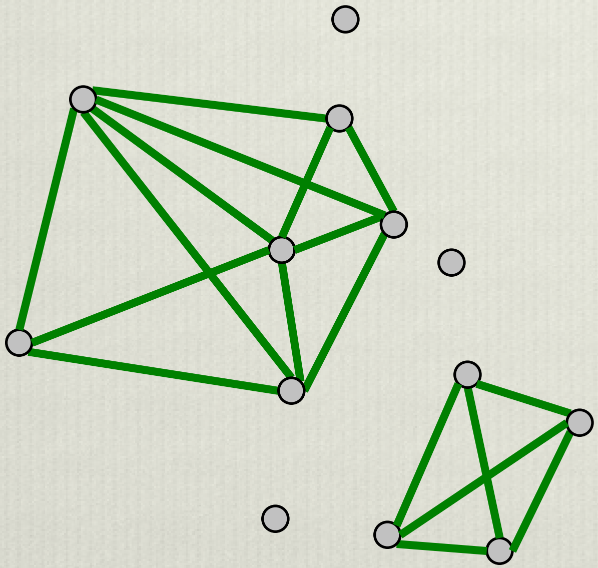


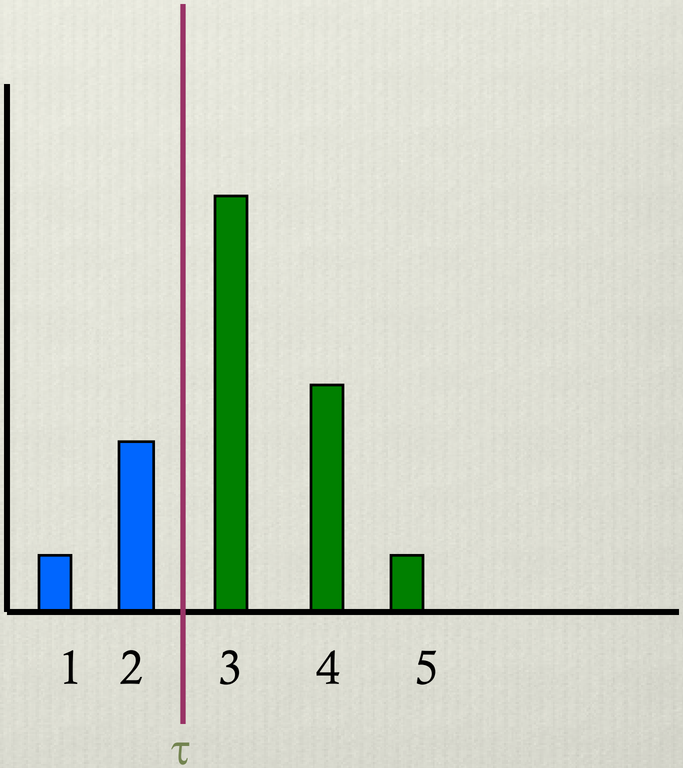


Metric-based filtering

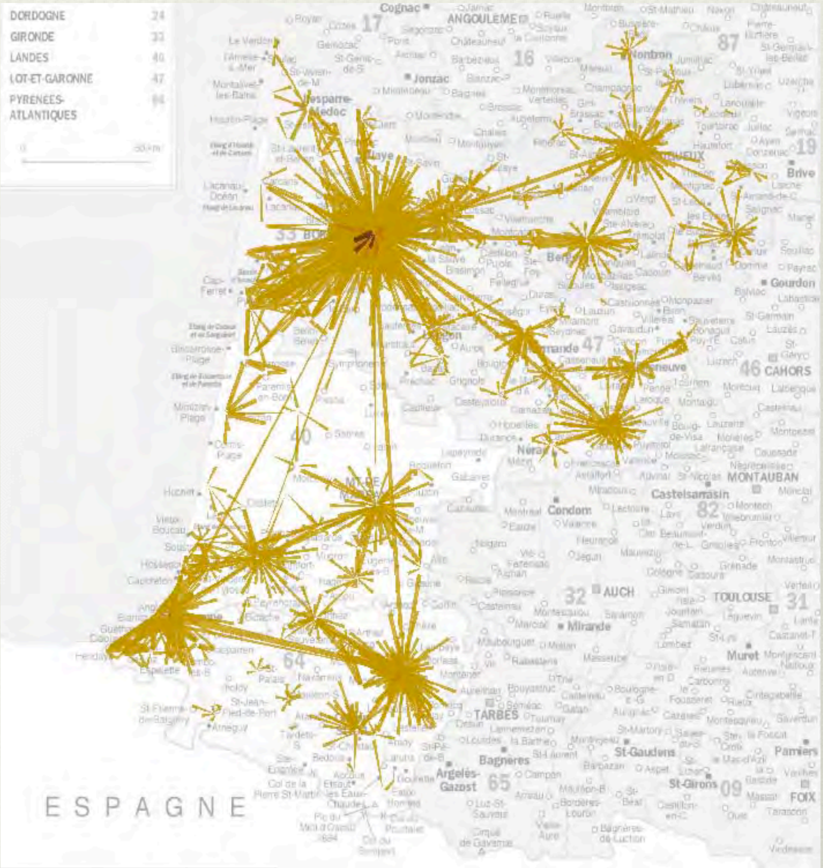
Provides a convenient way to achieve graph simplification.

Low-pass filtering : remove from G edges e such that $\Sigma(e) < \tau$.





Low-pass filtering removes "noise" in graph layout.

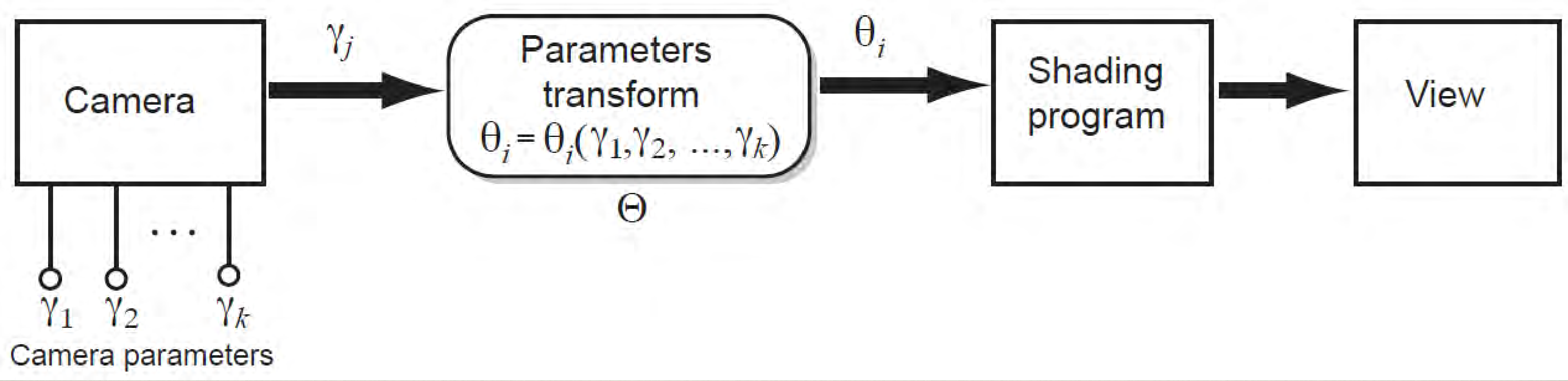


Commuter network for the Aquitaine region of France.

Filtering out links corresponding to 5 workers or less.

III. Camera state mapping

The idea is to **use camera parameters** (such as angle of view, distance between camera and point of interest, etc.) **to control graphical attributes** of objects used to represent the graph (such as link size, color, opacity, morphing parameter, etc).

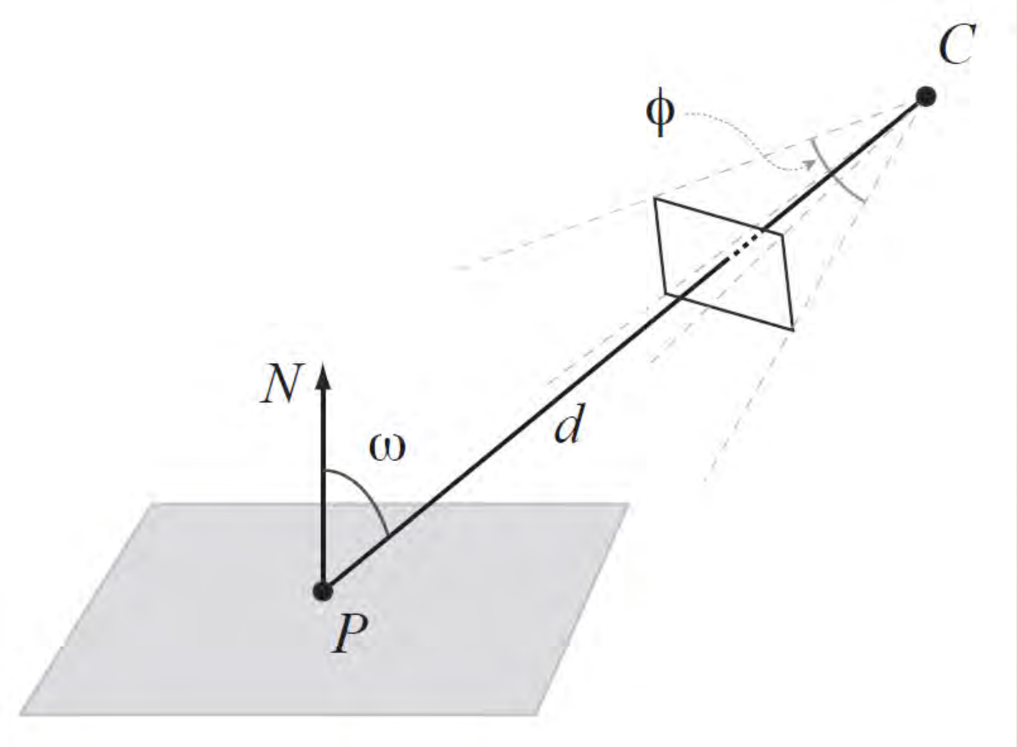


Typical camera parameters

ω : angle of view

d : distance between camera and point of interest

ϕ : field of view

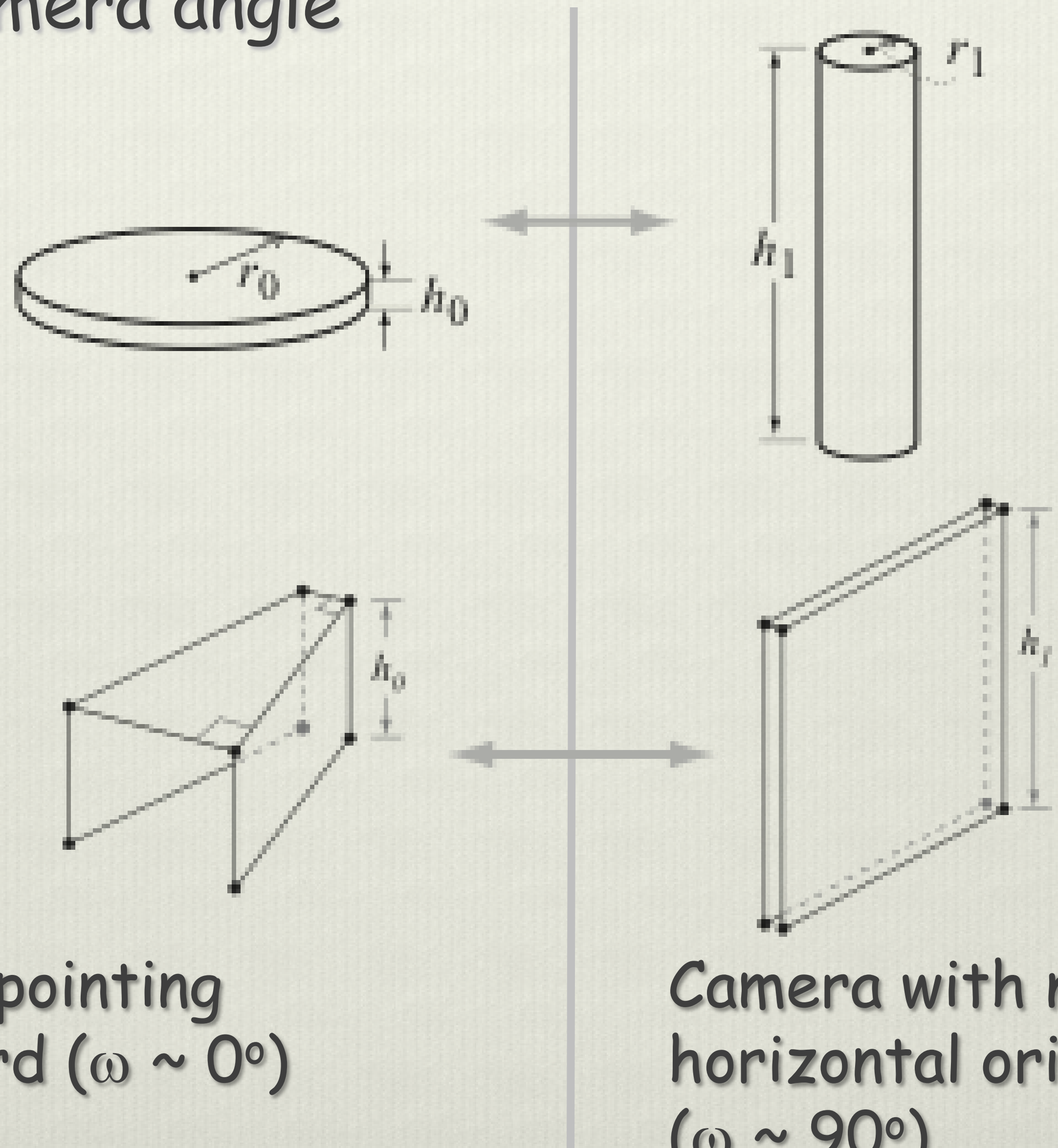


There are multiple graphical attributes (color, opacity, shape, etc.)…

Example 1 : Morphing links and nodes, in response to changes in camera angle

Nodes:

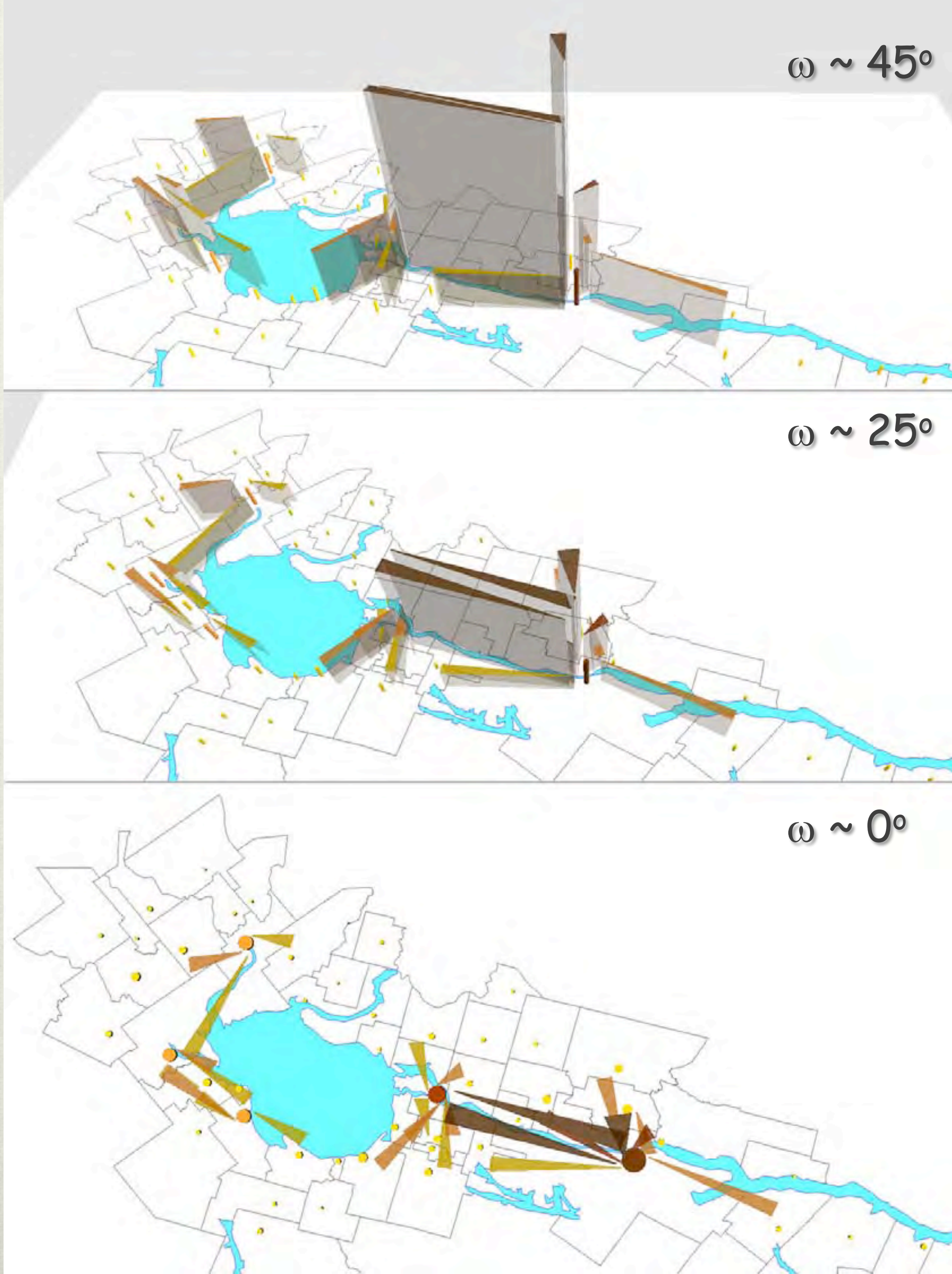
Links:



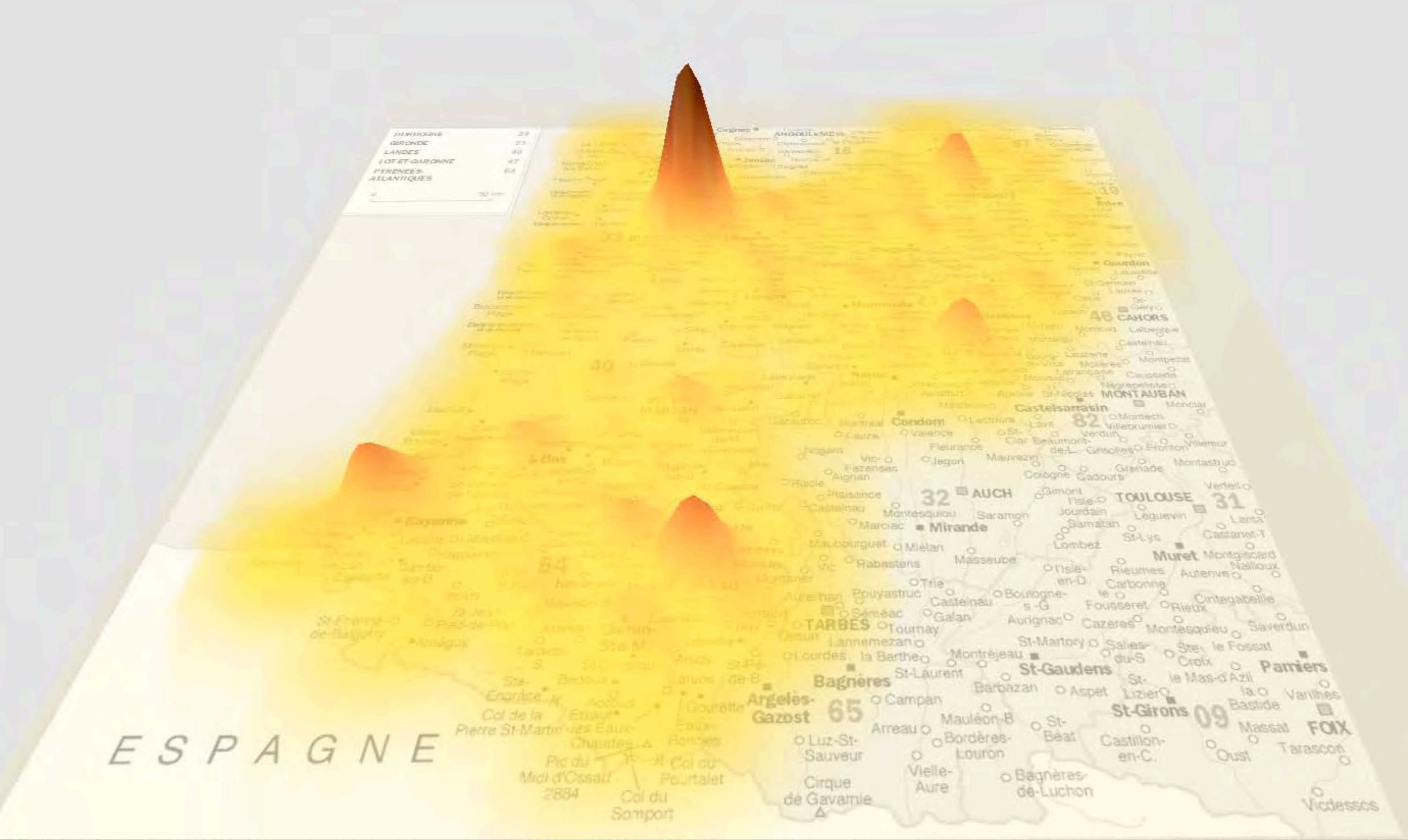
Camera pointing downward (ω ~ 0^o)

Camera with nearly horizontal orientation (ω ~ 90^o)

As the camera angle changes, we see a smooth transition from the 3D view to a 2D map.



Example 2: Surface representation of node metrics



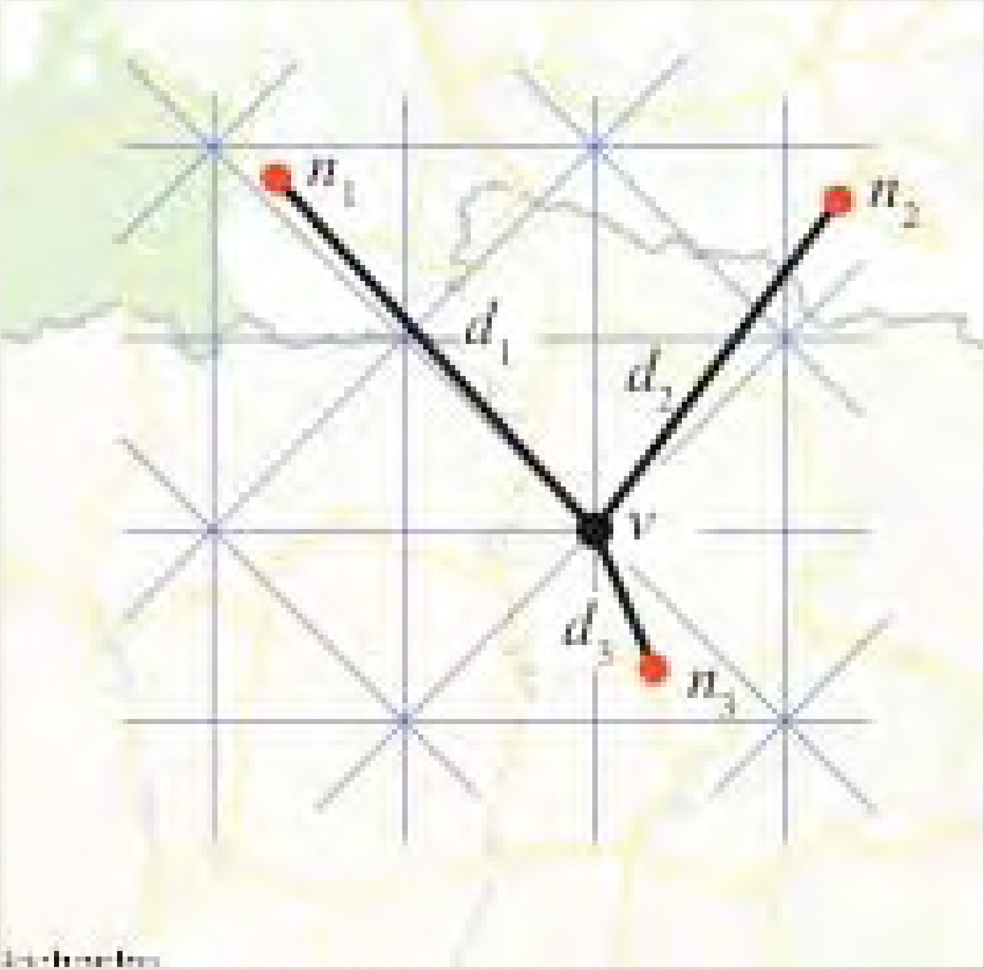
Height and color represent number of workers in towns.

Mesh calculation

We use a grid.

A priori, the height of each vertice v in the grid is determined by a metric value of nodes (cities).

For each vertex v, we sum the nodes' metric values weighted by an inverse exponential depending on distance between the vertex and nodes.



$$h(v) = \sum_i v_i e^{-k d_i}$$

v_i : node i metric value

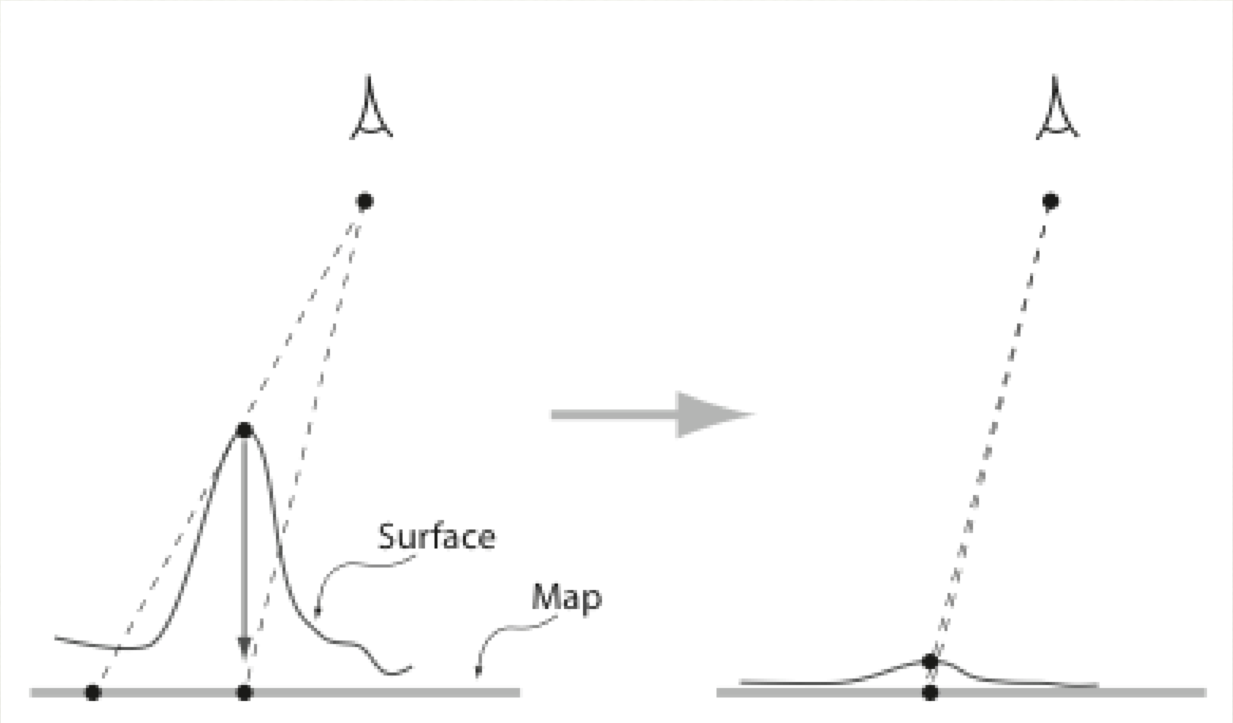
k : calibration constant

d_i : distance between node i and v

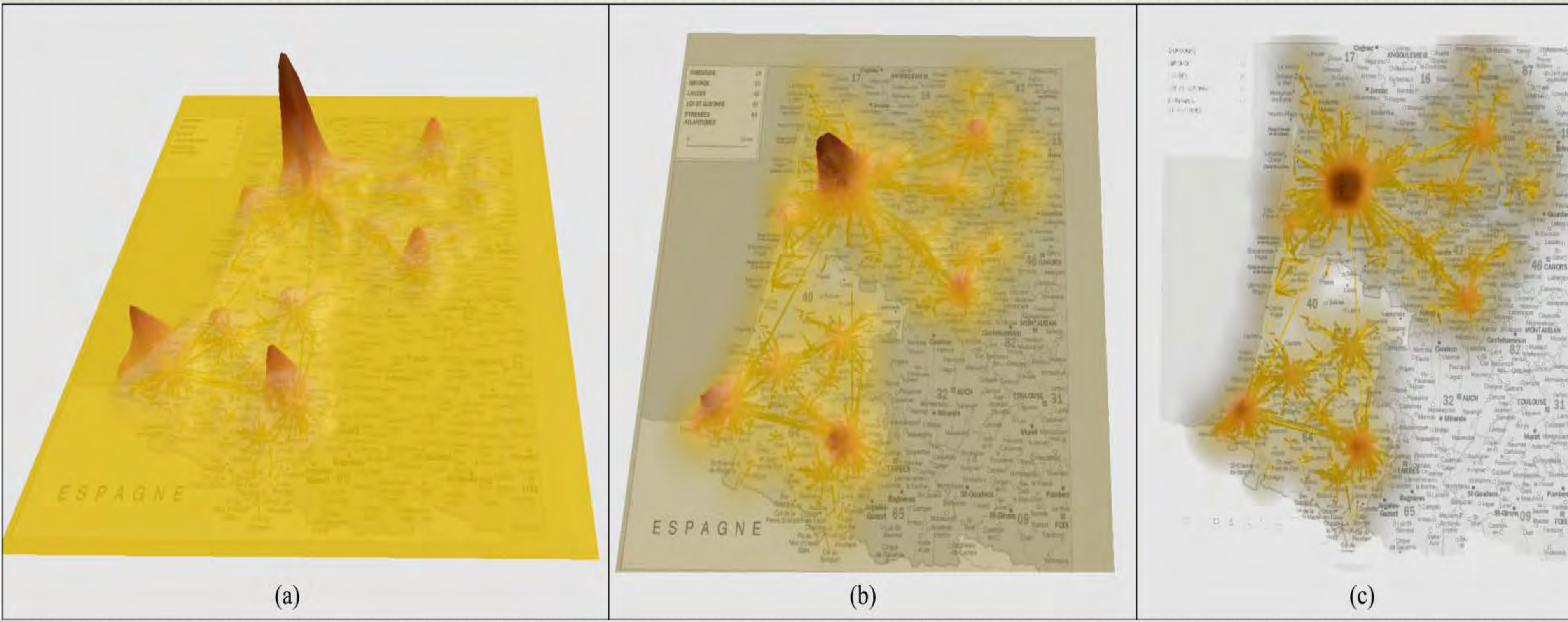
We use morphing, controlled by camera angle of view, to correct parallax.

The morphing acts by flattening the surface as the camera angle approaches the vertical.

The idea is to prevent the tops of surfaces from being shifted with respect to the underlying map image.



Using camera state to change opacity whenever 3D view transforms to a 2D map.



Opacity of the surface is determined by angle of view.

References

[1] A. Aris and B. Shneiderman. Designing semantic substrates for visual network exploration. *Information Visualization*, 2007.

[2] D. Auber. Tulip: A huge graph visualisation framework. In P. Mutzel and M. Jünger, editors, *Graph Drawing Softwares*, Mathematics and Visualization, pages 105–126. Springer-Verlag, 2003.

[3] D. Auber, Y. Chiricota, F. Jourdan, and G. Melançon. Multiscale visualization of small world networks. In *Proceedings of IEEE Symposium on Information Visualization (InfoVis)*, 2003.

[4] V. Batagelj and A. Mrvar. *Graph Drawing Software*, chapter Pajek - Analysis and Visualization of Large Networks, pages 77–103. Springer, 2003.

[5] B. B. Bederson and J. D. Hollan. Pad++: A zooming graphical interface for exploring alternate interface physics. In *Proceedings of ACM Symposium on User Interface Software and Technology (UIST)*, pages 17–26, 1994.

[6] A. Bezerianos, F. Chevalier, P. Dragicevic, N. Elmqvist, and J.-D. Fekete. GraphDice: A system for exploring multivariate social networks. In *Proceedings of Eurographics/IEEE-VGTC Symposium on Visualization (EuroVis)*, 2010.

[7] J. Binder, G. Haag, and G. Rabino. Analysis and modelling of commuter flows: application to the regions of stuttgart and turin. *Jahrbuch der Regionalwissenschaften*, (139):23–117, 2003.

[8] N. Burtnyk, A. Khan, G. W. Fitzmaurice, R. Balakrishnan, and G. Kurtenbach. StyleCam: Interactive stylized 3D navigation using integrated spatial & temporal controls. In *Proceedings of ACM Symposium on User Interface Software and Technology (UIST)*, pages 101–110, 2002.

[9] M. S. T. Carpendale, D. J. Cowperthwaite, and F. D. Fracchia. Extending distortion viewing from 2D to 3D. *IEEE Computer Graphics and Applications (CG&A)*, 17(4):42–51, 1997.

[10] Y. Chiricota, F. Jourdan, and G. Melançon. Metric-based network exploration and multiscale scatterplot. In *Proceedings of the IEEE Symposium on Information Visualization (InfoVis'04)*, pages 135–142, Los Alamitos, CA, USA, 2004. IEEE Computer Society.

[11] Y. Chiricota, G. Melançon, T. T. P. Quang, and P. Tissandier. Visual exploration of (French) commuter networks. In *Geovis*, Gerone, Spain, 2008.

[12] Y. Chiricota, T. T. P. Quang, and P. Tissandier. Développement d'un logiciel de visualisation et d'analyse de données à référence spatiale, 2009. Poster presentation at TheoQuant (Besançon, France).

[13] W. Cui, H. Zhou, H. Qu, P. C. Wong, and X. Li. Geometry-based edge clustering for graph visualization. *IEEE Trans. Vis. Comput. Graph.*, 14(6):1277–1284, 2008.

[14] G. Di Battista, P. Eades, R. Tamassia, and I. G. Tollis. *Graph Drawing: Algorithms for the Visualization of Graphs*. Prentice-Hall, 1999.

[15] M. J. Gauthier, M. Dion, C. Brisson, C. Chamberland, and A. Roch. Impacts of the realization of an electronic atlas in regions : the case of the saguenay-lac-saint-jean in quebec. *Cybergeo : European Journal of Geography*, 2003.

[16] R. Guimerá, S. Mossa, A. Turtschi, and L. A. N. Amaral. The worldwide air transportation network: anomalous centrality, community structure and citie's global roles. In *Proceedings of the National Academy of Sciences of the United States of America*, pages 7794–7799, 2005.

[17] I. Herman, M. S. Marshall, and G. Melançon. Density functions for visual attributes and effective partitioning in graph visualization. In *Proc. IEEE Symposium on Information Visualization (InfoVis)*, pages 49–56, 2000.

[18] I. Herman, G. Melançon, and M. S. Marshall. Graph visualization and navigation in information visualization: A survey. *IEEE Transactions on Visualization and Computer Graphics*, 6(1):24–43, January 2000.

[19] Y. Jia, J. Hoberock, M. Garland, and J. C. Hart. On the visualization of social and other scale-free networks. In *IEEE Transactions on Visualization and Computer Graphics*, pages 1285–1292, 2008.

[20] J. Kent, W. Carlson, and R. Parent. Shape transformation for polyhedral objects. In *Proceedings of SIGGRAPH*, pages 47–54, 1992.

[21] P. A. Longley, M. F. Goodchild, D. J. Maguire, and D. W. Rhind. *Geographic Information Systems And Science*. John Wiley, 2005.

[22] J. D. Mackinlay. Automating the design of graphical presentations of relational information. *ACM Transactions on Graphics (TOG)*, 5(2):110–141, April 1986.

[23] J. D. Mackinlay, P. Hanrahan, and C. Stolte. Show me: Automatic presentation for visual analysis. *IEEE Transactions on Visualization and Computer Graphics (TVCG)*, 13(6):1137–1144, 2007.

[24] G. Melançon and A. Sallaberry. Edge metrics for visual graph analytics: A comparative study. In *Proceedings of Conference on Information Visualization (IV)*, pages 610–615, 2008.

[25] T. Munzner. Process and pitfalls in writing information visualization research papers, 2008. A chapter (pp. 134–153) in Andreas Kerren, John T. Stasko, Jean-Daniel Fekete, Chris North, eds., Information Visualization: Human-Centered Issues and Perspectives, Springer LNCS Volume 4950.

[26] P. Mutzel and M. Jünger, editors. *Graph Drawing Softwares*. Mathematics and Visualization. Springer-Verlag, 2003.

[27] T. Nishizeki and M. S. Rahman. *Planar Graph Drawing*. World Scientific, 2004.

[28] R. Patuelli, A. Reggiani, S. Gorman, P. Nijkamp, and F. Bade. Network analysis of commuting flows: A comparative static approach to german data. *Networks and Spatial Economics*, 7(4):315–331, 2007.

[29] D. Phan, L. Xiao, R. Yeh, P. Hanrahan, and T. Winograd. Flow map layout. In *Proceedings of the IEEE Symposium on Information Visualization*, pages 219–224, 2005.

[30] R. J. Rost. *OpenGL Shading Language*. Addison-Wesley Professional, 2006.

[31] W. R. Tobler. Experiments in migration mapping by computer. *The American Cartographer*, pages 155–163, 1987.

[32] C. Viau, M. J. McGuffin, Y. Chiricota, and I. Jurisica. The FlowVizMenu and parallel scatterplot matrix: Hybrid multidimensional visualizations for network exploration. *IEEE Transactions on Visualization and Computer Graphics (TVCG)*, 16(6):1100–1108, November/December 2010.

[33] I. Viola, A. Kanitsar, and M. E. Gröller. Importance-driven volume rendering. In *Proceedings of IEEE Visualization (VIS)*, pages 139–145, 2004.

[34] C. Ware. Designing with a 2 1/2D attitude. *Information Design Journal*, 10(3):255–262, 2001.

[35] M. Wattenberg. Visual exploration of multivariate graphs. In *Proceedings of ACM Conference on Human Factors in Computing Systems (CHI)*, pages 811–819, 2006.

[36] D. J. Watts and S. H. Strogatz. Collective dynamics of small-world networks. *Nature*, 393, June 1998.

Thank you!