Schematizing Maps
SCORE project

Michal Young
University of Oregon

Preliminary Version

Abstract

Most geographic maps we use are designed to be fairly accurate with respect to distances and line or path orientation; they are drawn ”to scale”, with a uniform scale used throughout. However, there is another important class of (geographic) maps in which uniform scale is sacrificed for readability. The most famous of these is the ”tube map” of the London underground rail system, whose “schematic” style was introduced by Harry Beck in 1931. Today the schematic style is widely used, but not well-supported by map-making tools. The purpose of this project is to aid others in producing schematic maps.

1 Introduction

Most geographic maps we use are designed to be fairly accurate with respect to distances and line or path orientation; they are drawn to scale, with a uniform scale used throughout. There are both large commercial tools and open source tools for producing such maps from geographic data. However, there is another important class of (geographic) maps in which uniform scale is sacrificed for readability. The most famous of these is the "tube map" of the London underground rail system (see Figure 1, whose design principles have been adopted for most underground rail systems around the world. The general term for this kind of map design is schematic map.

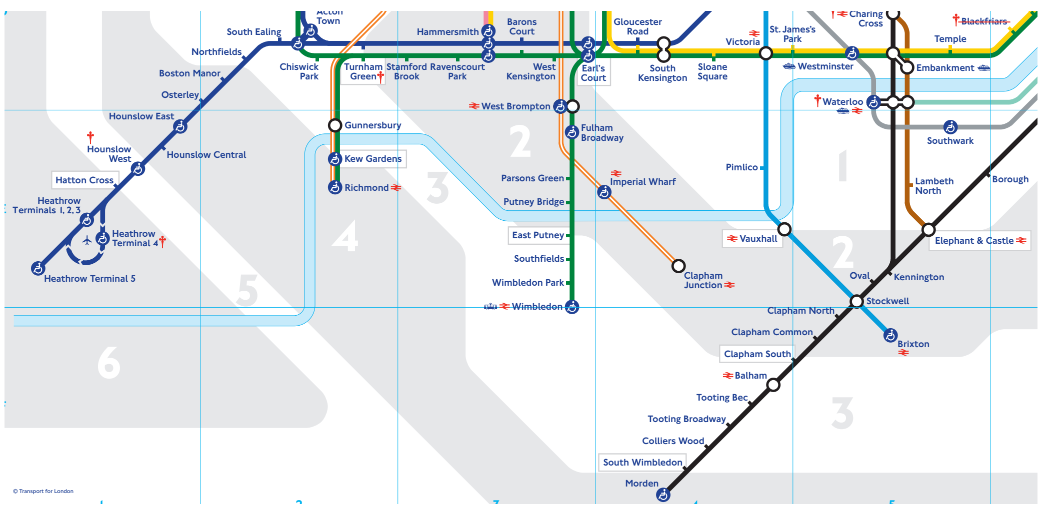

Figure 1: A portion of the standard London Tube map, available from tfl.gov.uk

To the best of my knowledge, there is much less support for creating schematic maps than for creating maps on a uniform scale.[1] You are challenged to create a system to help distort geographic relations to create a schematic map.

[1]ESRI dominates the commercial geographic information system (GIS) and cartographic tools market. ESRI markets an "ArcGIS Schematics" tool as an extension to their ArcGIS product line. ArcGIS schematics seems to provide either accurate geometry or none at all, while Beck-style schematic maps distort geometry but retain important geometric relations among topologically adjacent objects.

2 Goals

Your system is intended to help the designer of a schematic map. Such a designer may not be a full-time map designer. The designer might work at a local bus service and revise the bus maps once or twice a year, as routes change. The designer might even be a complete amateur, a member of a local bicycle club, producing maps to help describe bicycle routes for other cyclists. You are free to decide the level of professionalism in your target audience, and design a system that is appropriate for that audience. For example, the full-time designer of maps for a major transportation system will demand tools that are well-integrated with professional cartographic tools, while the person designing maps for a local bicycle club is more likely to create maps in a generic drawing program, perhaps by tracing over a screen-shot of a web-based map.

Whether your user is tracing over an image or extracting map features from a geographic database, the schematic map begins as a set of lines (and possibly also shapes) on a uniform coordinate system (which might be in lattitude and longitude, or might already be projected into planar coordinates). The purpose of your tool is to systematically transform it into a “schematized” version which is not to scale, but which retains at least some geometric properties of the original. For example, if labeled point A in the original map is south of labeled point B, then labeled point A should also be south of B in the schematized map, though it need not be as far south as in the original. Space may be squished non-uniformly, but general directions between at least some of the “important” points is preserved.

It is desirable, but optional, to simplify lines in the course of schematizing a map. In the London tube map, all lines follow an angle that is a multiple of 45 degrees (0, 45, 90, 135, ...). The Paris metro map uses 22.5 degree angles. Ability to choose the angle multiple would be a nice touch.

A more sophisticated schematizing transform might achieve further compression and simplification by sacrificing relative positions of some points that are not “close” or “connected” to each other. For example, the geometric relation between points stops on different metro lines is less important than the geometric relation between adjacent or nearby stops on the same line. Figure 2 illustrates.

A map schematizing system should, to the extent practical, interoperate with other tools for building maps. As noted above, the appropriate tools to interoperate with will depend on the user community. For example, a map designer for a major transportation system might want to use a sophisticated GIS system to

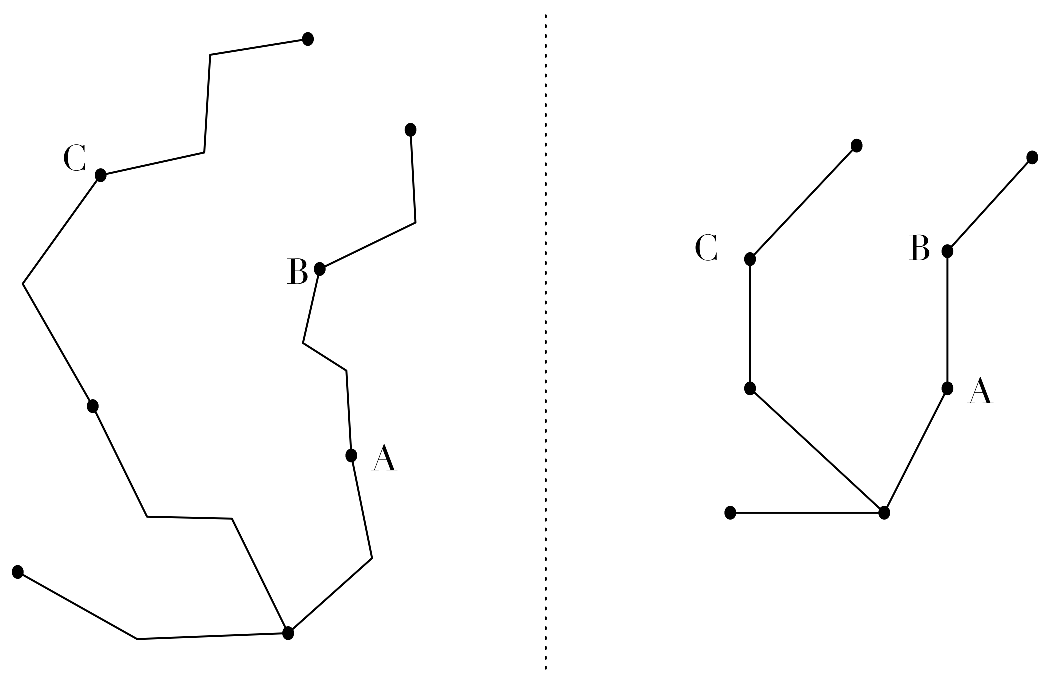

Figure 2: The importance of geometric relations depends on topograpical proximity. For example, if the figure on the left is the original map, C is northwest of B and B is north of A. In the schematized map at right, the relation of A and B is preserved, but the relation between B and C is distorted for compactness and readability.

construct an initial geographical form of a map, export it as ESRI shapefiles,[2] and then schematize it. He might then want to reimport it into a GIS application or at least into a drawing program for additional editing before printing or posting online. (In typical preparation of geographic maps, the final stages of preparation are done with a standard drawing program like Adobe Illustrator.)

Many amateur maps are created using online mapping services like Google Maps or Microsoft Virtual Earth, either directly (e.g., defining a KML path in Google Maps) or by exporting a map image as a layer in a drawing program and tracing paths or objects over it. Schematization would be valuable for such "home-made" maps as well, although it may be impossible to re-export a schematized map to the online mapping service. (We do not know of any online mapping service that supports non-uniform projections onto planar coordinates, or even allows the user to choose the projection used.) Export to a popular drawing program would be useful.

2.1 Scenario

We illustrate one possible way a map schematizing system might work. This is not the *only* way it might work, and might not be the *best* way for it to work, depending on the audience; teams are encouraged to think carefully about their target audience and creatively about how best to provide useful support.

The example we consider is producing a schematized map of a bus route, as illustrated in Figure 3, by tracing over a Google map as shown in Figure 4. We imagine a semi-automatic process in which a user indicates significant features in an overlay drawing, which will become the schematic map. The system would either import the line drawing and background image shown in Figure 4, or would provide a way to produce it.

One way to find potential simplifications is to find horizontal and vertical "slices" that do not include any of the significant features, as shown in Figure 5. The user may then select some or all of the slices to shrink or delete. Shrinkage may be proportional, or may be non-linear (e.g., logarithmic) with respect to the original size of each slice. The background image should be transformed in a way consistent with the foreground image (which will necessarily mean shrinking X and Y dimensions by different degrees). The user might also look at the slices and decide that additional areas need to be "protected", e.g., perhaps the point where the bus route crosses the I5 freeway (superhighway) ought to be added as a feature that

[2]See `http://en.wikipedia.org/wiki/Shapefile`

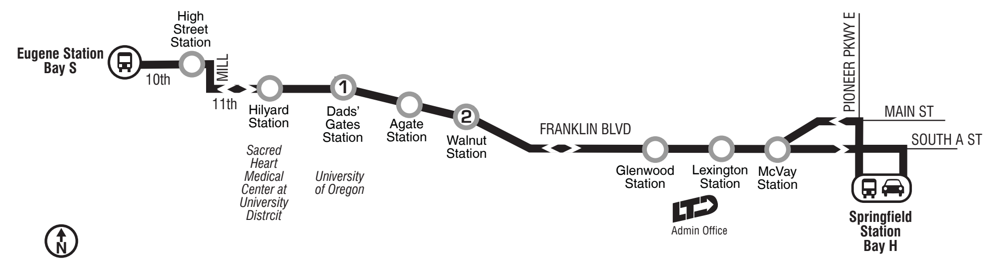

Figure 3: Schematic map of the EmX bus line in Lane County, Oregon, produced by Lane Transit District

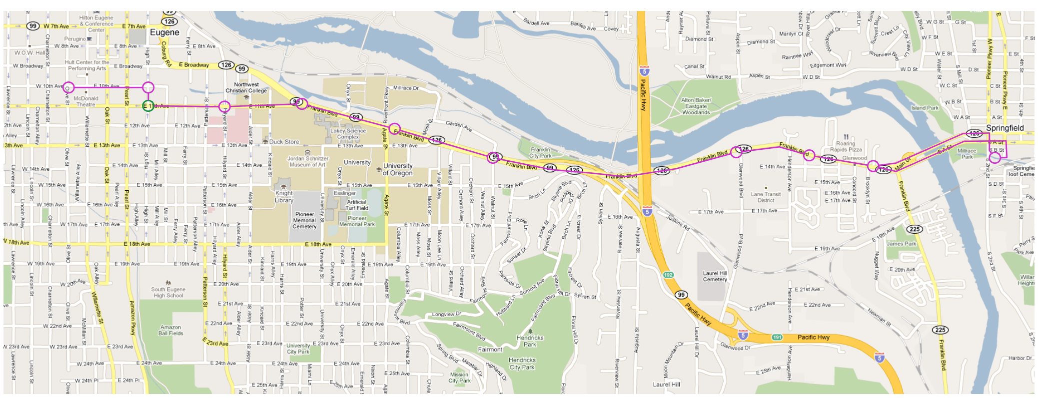

Figure 4: Route of the EmX bus line of Figure 3, traced over a Google Map image. The drawn map is more geographically accurate than the schematic map, but less useful.

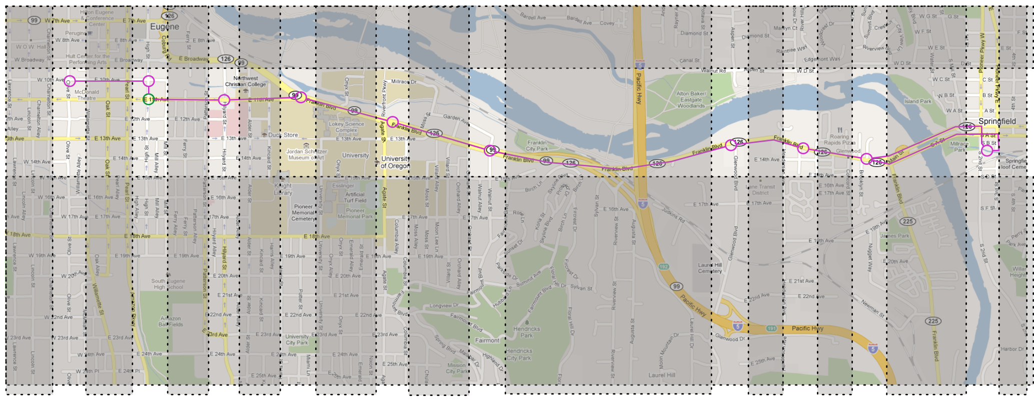

Figure 5: Route of the EmX bus line, with "slices" indicating sections that can be compressed or removed without violating topographic or geometric relations.

should not be part of a slice.

2.2 Variations

We have illustrated only horizontal and vertical slicing, but it is easy to see that sometimes a stripe at an angle to the map will be more effective, although they also require more sophisticated analysis to maintain spatial relationships among important points in the schematic.

We have described starting with a background image and drawing the route of interest by hand, but it would be useful to start from geographic data (for example, ESRI shapefiles) when they are available, or overlaying a route captured with a GPS. The OpenStreetMaps project (`//openstreetmaps.org`) might be a good source of open-source geographic data.

We have described a partially automated, interactive simplification process, but if the process were completely automated one could produce "fish-eye" views for mobile devices with GPS (e.g., many mobile phones), providing full geographic representation in the vicinity of the user and schematic representation outside the immediate vicinity.

Some schematic maps also include a drawn background map that becomes part of the schematic map. The Washington DC Metro map, for example, shows the Potomac river in a manner that is highly simplified but still suggestive of its relation to surrounding features. The London Tube map likewise includes the Thames but simplifies its route. Such a drawn background should not be treated precisely like the foreground schematic nor exactly like the background map. While a background like the Google map shown here is purely for reference by the map artist, and is not part of the final map, a drawn background is intended to be part of the final map. However, unlike the schematic path overlay, vertices or point features in the drawn background may be part of a region that undergoes shrinkage. The Potomac river remains part of the DC Metro map, but many of its details may be lost in simplification.

3 Tools and Standards

The appropriate tools and standards depend on the intended target audience, as described above. Teams are strongly encouraged to use existing open-source software components if doing so will allow them to focus on providing new support for schematization rather than reproducing functionality that is already widely available. Interoperating with commercial tools is often desirable; this could be anything from a cartographic design system to an illustration program or even a commercial but free-to-use web-based mapping system. Incorporating components that require a commercial license is appropriate only if the target audience is likely to find them inconsequential.

4 Intended Outputs

Clear documentation of the intended audience and a rationale for the external system design for that audience is a must.

A fully implemented and documented system with limited features is preferred to an elaborate design that has only been partly or poorly implemented. Better yet is a solidly designed and implemented core system that is not only useful in its present form, but is a basis for future extension and enhancement. This implies very good documentation of the architectural design, and good technical documentation throughout.

5 Stakeholder Interaction

The project proponent is happy to undertake a modest level of communication with student teams. Initially teams should interact with the proponent by email (michal.young@gmail.com), and he will attempt to reply to most email within one week. If the volume of email interaction becomes a problem, or if the same issue is raised by many participants, the discussion may be moved to a blog.

Teams are encouraged, but not required, to find a real potential user of a schematic map construction system, and to develop appropriate system requirements and design for that user.