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Mental Map Preservation for Progressively Labeling Railway Networks

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ABSTRACT

Schematizing railway networks for better readability is often achieved by aligning railway lines along the octilinear directions. However, such railway map layouts require further adjustment when placing station name labels. In this article, the authors present a novel approach to automating the placement of station names around the railway network while maximally respecting its original layout as the mental map. The key idea is to progressively annotate stations from congested central downtown areas to sparse rural areas. This is accomplished by introducing the sum of geodesic distances over the railway network to properly order the stations to be annotated first, and then elongating the line segments of the railway network while retaining their directions to spare enough labeling space around each station. Additional constraints are also introduced to restrict the aspect ratios of the region confined by the railway network for better preservation of the mental map.

KEYWORDS

Geodesic Distances, Mental Maps, Mixed-Integer Programming, Progressive Annotation, Railway Maps, Schematic Layouts

INTRODUCTION

This article presents a progressive approach for automatically annotating stations with their names while maximally respecting the original layout of the schematic railway map. This is accomplished by extending the authors' previous work (Yoshida et al., 2018) for placing station names progressively as annotation labels from crowded downtown areas to sparsely-populated rural areas. The authors implemented this labeling scheme by computing the geodesic (i.e., shortest topological) distances of each station from the other stations through the railway network, and sorting the stations in terms of

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the sum of such distances for the progressive annotation. To faithfully aligning station names along one of the octilinear directions, the proposed approach elongates railway line segments of the original schematic network while retaining their original directions so as to spare enough labeling space around the stations in the schematic map. Furthermore, this article specifically differs from the previous work (Yoshida et al., 2018) in that the approach imposes additional constraints that restrict the variation in the aspect ratio of the regions confined by the railway network, which allows maximal retention of the mental map from the original schematic map. The feasibility of this work will be demonstrated through side-by-side comparison between the results of previous and new approaches, together with evaluation through an informal user study.

Figure 1 shows how name labels are progressively placed around the corresponding stations in a schematic railway map. Suppose that we take an octilinear layout of a railway network as input as shown on the top-left of the figure. The annotation process begins with labeling stations in the congested downtown area around the center of the map, including interchange stations. The station name labels are placed one by one while stretching the railway line segments to spare more labeling space when necessary. This process can successfully label all of the stations while retaining the overall layout of the schematic railway network given as input, as shown on the right-bottom of Figure 1.

Background

Railway maps serve as the common media for travelers to explore the transportation networks of the railway lines available in major cities. Such maps are often transformed into schematic diagrams for better readability of the network topology. In particular, octilinear layouts are the most representative form, which is obtained by aligning railway line segments to horizontal, vertical, and 45-degree slanting directions. This representation originates from the design criteria invented by Henry Beck (Garland, 1994), an English engineering draftsman famous for his London underground tube map

Figure 1. Metro network in Lyon. Station names are placed from the map center while adaptively extending railway line segments for sparing enough labeling space.