Towards Presenting Travel Times in a Bus Network as Immersive and Adaptive Data Stories

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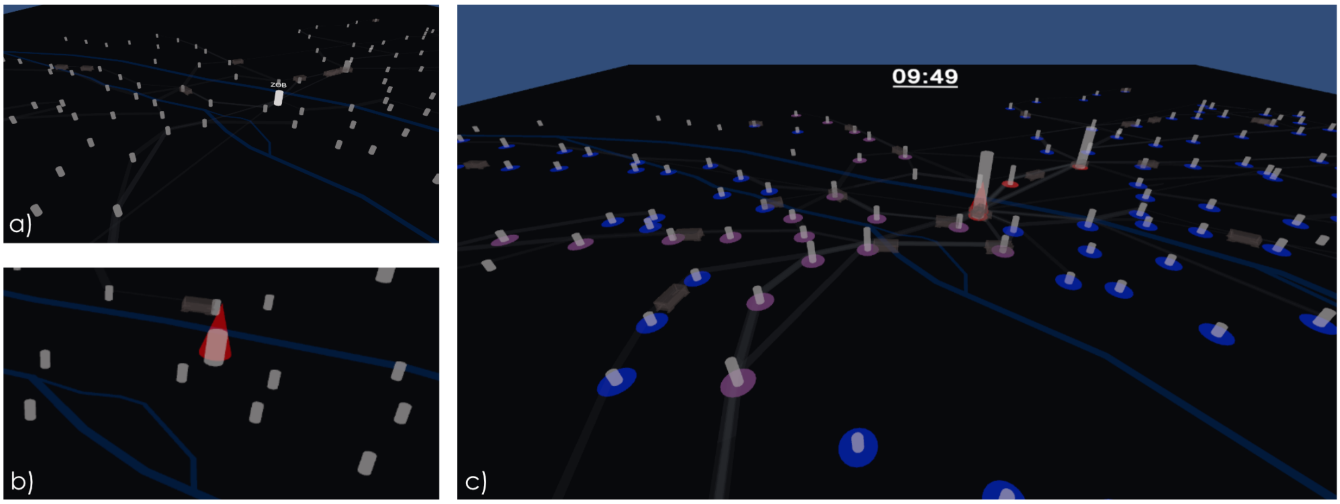

Figure 1: *The process of simulating travel times: a) The animated bus network, hovering over the stop "ZOB", b) placing the virtual passenger (cone) to select a stop, c) the color-coded travel times after 60 minutes simulation time.*

Abstract

Desirable increased usage of public transport is, to some extent, limited by people being unaware of their traveling options. To invite a broad audience to casually explore their local bus network, we present an approach for the interactive analysis of traveling times in an immersive, animated simulation of buses. A first prototype already implements the core travel time visualization for a personal starting point. Additionally, we outline specific plans to extend the system towards telling adaptive stories that summarize the data and guide the users to relevant insights.

1. Introduction

Public transport plays a crucial role in achieving climate neutrality in a city. Therefore, it is important that citizens understand public transport options, such as which places in the city they can reach in a reasonable time. Travel times computed from a certain starting point can be presented in travel time maps, as colored regions, lines, or markers overlaid on the map (e.g., Figure 2). Even if not particularly difficult to understand, such maps might, in a sense, *scare* people through their visual complexity and unfamiliarity. They also lack a casual character that invites to play with the data and do not explain which lines need to be taken to reach certain points.

In contrast, in this paper, we present an approach that makes travel time analysis more accessible and inviting to the public. Leveraging the enhanced spatial understanding and engaging immersion of virtual reality (VR), we simulate the bus network of a city in real-time and visualize stylized buses and bus stops on an abstracted map (Figure 1a). After selecting a stop that represents a starting point (Figure 1b), we visualize the temporal reachability of the different bus stops in a bus network. When a bus that the virtual passenger could have taken reaches a stop, a marker is placed (Figure 1c). These markers are colored based on the time it took for the passenger to reach it. Hereby, we create a travel time map the user can recognize from a distance, and through the an-

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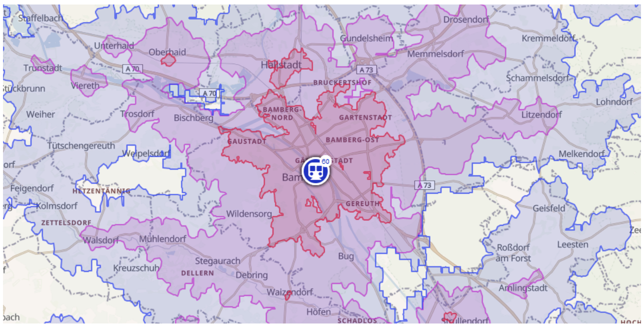

Figure 2: *Public transport travel time map for a central location in Bamberg, Germany with regions marked reachable within 20, 40, and 60 minutes; created through* `https://commutetimemap.com`.

imated constructions, users can follow its construction. Adapting and extending existing solutions integrating data stories into VR environments [LTB22, KSM*23], our approach further targets incorporating elements of storytelling and generative AI. We therefore aim to create an immersive and engaging experience that not only presents transportation data, but also narrates stories that dynamically adapt to user interactions. While there are various analytical visualizations to investigate and compare travel times (e.g., [ST13, ZFA*14, GKV21]), we are not aware of other, casual or immersive travel time analysis approaches described in the literature. The simulation of the bus network in VR, including the travel time visualization, has already been implemented in the current prototype (Section 2; supplemental video). However, adding a dynamically generated story is only outlined as a concept (Section 3).

2. Visualizing the Bus Network

The prototype is built in Unity for the Meta Quest platform. In a single 3D scene, it simulates the bus network of the city of Bamberg, Germany, based on the official bus schedules. An abstract map, laying on a virtual tabletop, shows rivers as geographic reference (Figure 1a). Bus stops are visualized as cylinders at their geographic location, with their names displayed on hover. In the simulation, we animate the buses in smooth transitions on straight lines between stops according to their scheduled arrival and departure times. The buses spawn at their starting stop, travel through all stops on their route, and terminate upon reaching the final destination. Collisions with other buses or objects are not considered. When a bus reaches a stop, the height of the stop's cylinder increases by a constant, while all cylinders shrink by a small factor in each time step. This creates a height-encoded visualization of visiting frequencies, which automatically adapts similar to a moving average and provides more geographic references as main bus stops become clearly visible. The buses leave trails that slowly fade out so that a network-like structure appears, which automatically adapts, for instance, to different line routes at different times of the day. To avoid unnecessary visual complexity and deal with occlusions, all items placed on the map are semi-transparent (and light emitting), so that buses and stops remain visible even in dense areas. For the trails, hence, stronger lines indicate frequent routes.

To visualize particular travel times, the user first chooses a starting point by selecting a stop. A virtual passenger appears as a simple red cone at the stop (Figure 1b). It boards every bus that it could take, as well as all possible connecting buses. If a boarded bus reaches a stop the passenger has not visited yet, a marker is placed and colored according to the travel time. To simplify and create clearly visible isochrone areas (Figure 1c), we divide the travel time into three intervals of 20 minutes, colored in red, purple, and blue (cool down metaphor). To visualize this even clearer, the buses that carry a passenger are also colored in the current travel time color. In comparison to a static travel time map as shown Figure 2, this method dynamically unfolds a similar map, while users can observe which bus lines the virtual passenger takes and which hub nodes might be most relevant for connecting lines. The resulting maps are tailored to a specific starting point and start time.

3. Towards Adaptive Storytelling

While the prototype already provides a usable VR solution for casual travel time analysis, we want to extend its appeal and outreach potential by developing it into an interactive story. Our final goal is to have an adaptive audio guide with narrated story elements [LTB22] based on the dynamically created travel time maps presented above. To ensure clarity of the visualization, different stages are triggered by the three time intervals. At each stage, the simulation is paused and stops reached in the previous interval are visually highlighted. Meanwhile, a dynamically generated story is narrated, focusing on the stops or their surroundings. To ensure every story is unique, we might not use common text templates, but plan to generate the text through an AI based on the provided data input. The text will then be narrated through a text-to-speech service. While the narration plays, we also intend to implement soundscaping for suitable stops. For instance, the user will hear trains at the railway station and bird singing at a stop near a main park. The stops that are highlighted and used to generate a story can be selected with local knowledge of major points of interest. Additional value could be created through extending the approach with a comparison of different travel modes (e.g., walking, biking, taking a car). However, new simulation modes will need to be developed, along with dynamic visualizations of the unfolding traveling times. Personalization might become relevant, as availability and preferences for different modes might be passenger-specific (e.g., somebody might not own a car, but is a sportive cyclist). Results to report and summarize in the story will become much richer and less obvious to users. Finally, user feedback is important to ensure the effectiveness and usability of the prototype. We therefore plan to conduct an evaluation with citizens of Bamberg, which will assess not only the functionality of our solution, but also people's motivation to try out new modes of transport. The study can be embedded into an exhibition of the VR-based data story at a public space (e.g., an entrance hall of a public building).

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