SRC: An Intelligent and Interactive Route Planning Maker for Deploying New Transportation Services

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ABSTRACT

In this work, we propose a novel system, called Route Planning Maker (RPM) to help the government or transportation companies to design new route services in the city. The RPM system has a flexible user interface that allows users design the nearby areas of a new route and further deploying new stations. Moreover, based on user-designed arbitrary transportation routes and the expected locations of stations, the RPM system provides an intelligent function to infer passenger flows in certain time intervals so that the user can estimate the effectiveness of designed routes. To capture the spatial-temporal factors correlated with passenger flows, we propose to combine dynamic features such as human mobility, passenger volume of existing routes, and static features, including road network structure, point-of-interests (POI), station placement of existing routes and local population structure. Finally, to combine these features, we modified Deep Neural Network (DNN) for regression to derive the passenger flow for each given designated route. The experiments on the Tainan's bus-ticket data outperform baseline methods for 75%.

CCS CONCEPTS

• Information systems → Location based services;

KEYWORDS

Transportation Route Planning, Interactive Route Design, Passenger Flow Inference, Urban Planning

1 Introduction

The developments of traffic and human life are closely related. To reduce heavy traffic, the government usually deploys new services such as station and route construction. However, misestimating the demand for a certain route or a station could lead to serious impacts for both the government and people. Therefore, we aim to develop an efficient way to assess the benefit of a new route service in advance before deployment. We propose a novel system, Route Planning Maker (RPM), with two main functions. The first one is about the interactive route design and the second one is related to passenger volume inference. The system interface is shown in Figure 1.

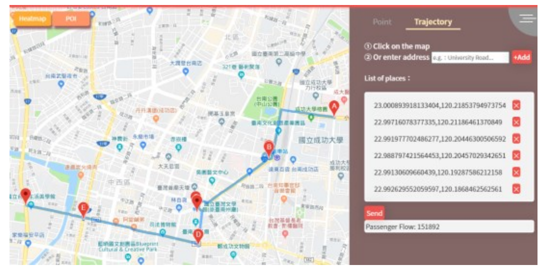

Figure 1: The proposed RPM system.

It is obvious our proposed RPM system could be exploited in many kinds of urban transportation, such as subway and taxi routes. The first function is that we allow users to design their arbitrary preferred routes segment-by-segment and the RPM system can visualize both new and existing routes in the map, which is quite useful for realizing the nearby area of a new route service. The second is to infer the passenger volume of a designated route. This can help to estimate the potential effectiveness. We propose several strategies to support the second function. To our best knowledge, no existing work has such contributions. First, we believe features observed in its route-affecting region (RAR), which indicates the influential range of a route, would influence the passenger flow (PF) of the route. Second, we exploit and modify the idea from DNN for regression to do PF inference. Third, to address the effects among new routes and existing ones, we divide each route into multiple segments and analyze the impacts by Dynamic Time Warping (DTW). The experiments show that our method outperforms state-of-art and baseline methods.

Related Works. Some works [2][6] focused on decreasing transportation time through route adjustment and shift. There are also some works [4][8] that optimized the route planning, in which distance, time, transference and passenger flow were considered. On the other hand, some work [1][3][5][7] studied the problem of predicting arrival time for public transportation based on regression methods. Moreover, some research [9][10] focused on the problem of predicting future passenger-flow. However, these works focus on existing routes, which are not our target problem.

2 Methodology

System Interface. The RPM system for users to schedule routes and stations is designed. The interface is shown in Figure 1. The system has three functions: (a) Map for users to schedule routes and stations. (b) Control panel for users to add or delete certain stations and adjust radius for RAR. (c) The PF of the route will be inferred to users.

Problem Definition. Given a set of trajectory for designated route with its stations labeled from users, our goal is to infer the passenger flow $PF(l_i t_j)$ for each segment l_i of the routes in certain time interval t_j. In other words, we devise the RPM system for users to schedule their own routes and stations. Then, the system derives the passenger flow of the user-designated trajectory and stations in a certain time interval.

2.1 Route-Affecting Region

The demand for public transportation is not only based on the origin and destination, but also the nearby geographical environment and urban functions of nearby area. Thus, we propose RAR for taking passenger-flow related features into account. A route can comprise multiple segments which contain successive points close to each other. Then we can draw a circle for each point, where we consider each point as the center of a circle, and then RAR formed by set of circles.

2.2 Feature Extraction Based on RAR

To correctly infer the PF of the trajectory, we consider six kinds of relevant urban features in RAR:

2.2.1 POI-related features. Various POIs (specific point location such as transportation spots or entertainment venue) and their density in RAR indicate the function of a route, which might have high correlation to PF of a route. We consider three kinds of POI features.

POI Density. The density of POI indicates the popularity of a certain activity type in *RAR*.

POI Entropy. The POI entropy in RAR shows the diversity of purpose for people to visit the nearby area of a route.

Competition of Similar POI. Similar transportation-related POIs might cause a competitive relationship between two routes.

2.2.2 Human mobility. Human mobility includes three ways, the transition density, incoming flow, and leaving flow in RAR.

2.2.3 Road network structure. We exploit road network structure since it might have correlation with real traffic condition. The degree and closeness centrality of road network in RAR are considered.

2.2.4 Competition and Transference with existing routes. Two routes might cause competitive relationship if their RAR is similar. However, intersected routes with considerable extended segments would encourage passengers to transfer between them. We analyze the impacts on passenger volume among the segments by DTW.

2.2.5 Population structure. People in RAR for different ages and genders have different intentions for taking public transportation.

2.2.6 Time Information and Granularity. Seasons and holidays can influence the passenger flow of the public transportation.

2.3 DNN Inference Framework

We adopt and modify DNN for regression to derive the PF for designated route. However, due to page limit, we skip the details here.

3 Experiments

We use the bus-ticket data from Tainan City Government for the evaluation, which contains 14,336,226 ticket records. The city bus system holds 104 routes and 6575 stations; meanwhile, each ticket record lists route and time information, starting and ending station. We have two kinds of experimental scenarios, the first one is querying only a route (trajectory-based), and the second one is a route with deployed locations (station-based). We develop four compared methods: (a) *Average value* and (b) *Median value* calculates the average and median value of the PF for all training routes respectively. (c) *XGBoost* and (d) *Support Vector Regression* considers only distances with existing routes. The performance result based on normalized RMSE with leave-one-out evaluation is shown in Figure 2.

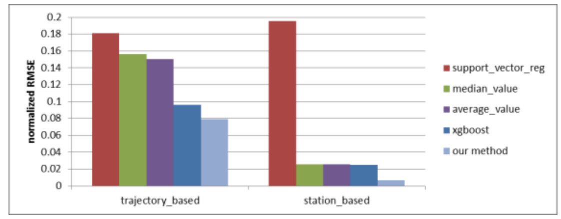

Figure 2: Normalized RMSE of PF results for different methods.

4 Conclusion

This work proposes an intelligent and interactive system called RPM to let users design novel routes and infer the passenger flows based on current bus routing and ticket data. The novelty of this work is two-fold. First, no existing work addressed the problem of arbitrary route design. Second, given heterogeneous features and faced with the competitive and transfer effects of existing routes, our proposed RAR and feature engineering methods are more effective for handling dynamic and static data. The experiments on Tainan City bus-ticket data outperform baseline methods for 75% in station-based scenario.

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