Developing an Eco-Cooperative Real-time Taxi Allocation System

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Taxicabs serve as an important component of the contemporary urban or metropolitan transportation system since they cater to a large demand, cover a wide geographic area, and offer highly flexible mobility service. By 2013, 13,437 yellow medallion taxicabs in New York City (NYC) transport more than 236 million passengers. However, conventional taxicab operation may suffer from vacant trips while hunting for passengers, which reduces the operational efficiency, leads to longer passengers' waiting time, and brings extra burden to the urban roadway system in the form of congestion and greenhouse gases (GHG) emissions. According to the 2014 Taxicab Fact Book, only an average of 60 % of taxicabs are occupied in NYC during peak hours, which will further decrease to around 50 % at night.

Compared with taxi services, most of public transit services such as buses and subways are designed with dedicated stations and travel routes. Despite lack of flexibility, public transit can provide more reliable and stable travels. Since the stations and routes are usually pre-optimized subject to the expected demands at the planning stage, public transit may well avoid the risk of waste in operational cost due to vacant trips. This helps improve the performance of urban transportation systems by reducing traffic congestions and GHG emissions.

In this research, an eco-cooperative real-time taxi allocation system has been developed to combine the flexibility of taxicabs and the efficiency of public transportation. Once a taxicab drops its passenger(s), the system will navigate it to next "virtual station" with the largest likelihood to pick up passenger(s). These virtual stations will be set up according to the current traffic conditions and demand-supply gap by taking advantage of flexibility of the taxi system. In order to better model the taxi system, historical taxi trip data will be collected and analyzed to recognize the pick-up demand patterns with respect to both time and positon. A deep learning method called Long Short-Term Memory (LSTM) Networks helps to precisely predict the taxi pick-up demand. Leveraging the advantage of public transit with taxi can potentially reduce vacant time and vacant travel distance wasted for looking for customers. This would also result in improved transportation efficiency, reduced emissions, effective matching of passengers and taxis as well as the potential to satisfy the same demand with fewer number of taxis.

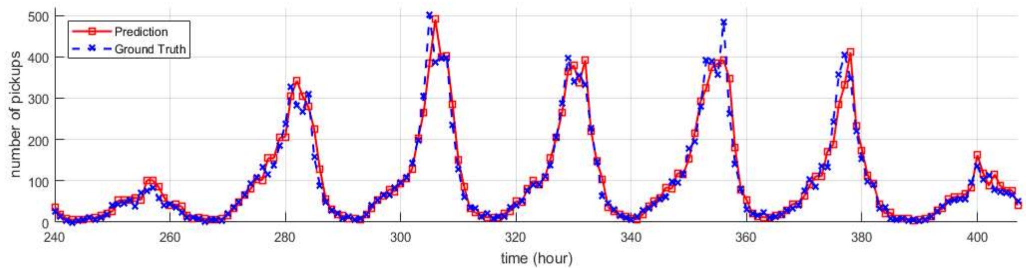

Figure 1. Prediction result by LSRM (10th week of 2015, Midtown Center, NYC).

Different from a ride hailing system (like the service Uber offers), our eco-cooperative real-time taxi allocation system gets involved all the taxis inside the system and builds protocols for them to work cooperatively. Instead of making their own choices, the system aims to find a global optimum to solve the problem of mismatch of demand and supply. The taxi demand is learned from historical data and keeps updated in a closed-loop manner.

The dataset used for this study is taxi trips record data of New York City (NYC) from January 2010 to June 2013 released by NYC Taxi & Limousine Commission (TLC). The records include fields capturing pick-up and drop-off dates/times, pick-up and drop-off locations, trip distances, itemized fares, rate types, payment types, and driver-reported passenger counts. We also use a digital NYC map to pin down the drop-off and pick-up locations for better understanding the travel demands in the city.

The preliminary result of this research shows a reduction of 47% in the vacant trip time with the proposed taxi allocation system. This indicates that our system is a feasible method to improve the utilization of taxicabs and hence provide a more efficient transportation service.

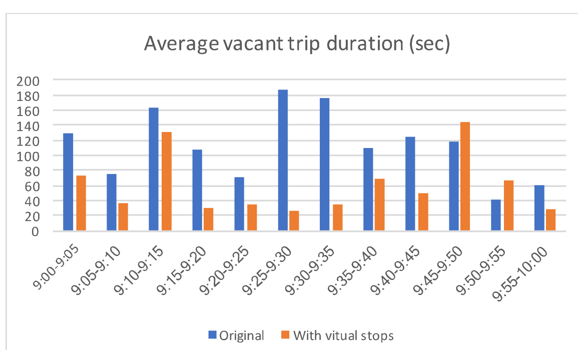

Figure 2. Comparison result of vacant trip duration