UTC Project Information	
Project Title	R2Deep: Recharging Recommendation System for Electric Taxis based on Deep Learning
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Brief Description of Research Project	Electric taxi (eTaxi) often face an inherent long waiting and recharging time (e.g., in hours) at charging stations. Therefore, where to charge and how long to charge an eTaxi has already emerged as an urgent and crucial problem to be solved for wide deployment of eTaxis. In this project, we propose to develop a recharging recommendation system based on deep learning, called R2Deep, for eTaxi drivers to improve their operational efficiency as well as increase the revenue of both eTaxi drivers and companies. The project has three tasks: 1) analyze the existing eTaxi GPS trajectory data and convert them into information on the grid maps, which will then be directly fed into our deep learning models; 2) utilize deep learning techniques including both Recurrent Neural Network (RNN) and Convolutional Neural Network (CNN) to learn latent patterns behind eTaxi data sets and provide real-time suggestions on recharging time and charging stations to eTaxis drivers; 3) evaluate our R2Deep model, analyze its performance (e.g., the recommendation accuracy, increase in the eTaxi drivers and companies' revenue, average reduction of waiting time at charging stations, etc.) with real world data.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	The study is performed on the eTaxi deployment in Shenzhen, where the number of eTaxi was approximately 700 in 2017. We have collected data on deployment of charging station, where the total number of charging station is 187 (increased from 53 in 2014). The distribution of deployed charging stations for eTaxis is shown in Fig.1.

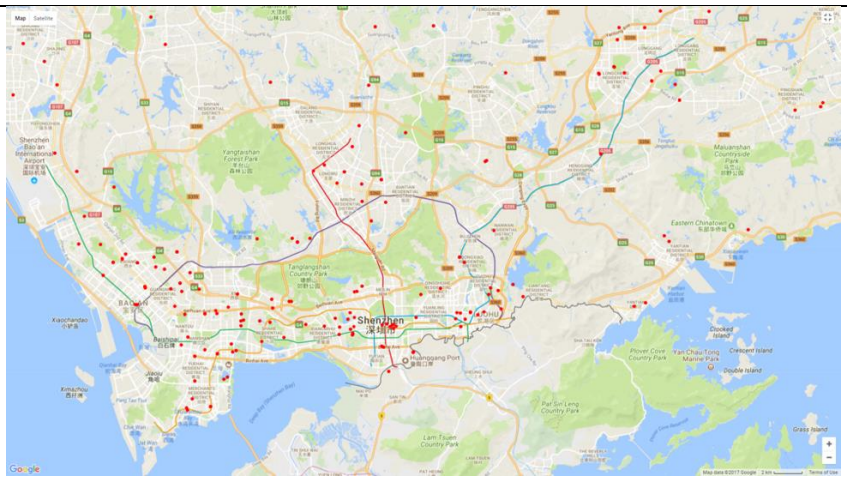


Fig.1. Charging Station Map of Shenzhen

By mapping the geospatial movement of cars to the positions of gas stations, it may appear that refueling events can easily be discovered. However, due to the noisy and missing data of the GPS reading, it is not a trivial task at all. Thus, we extract refueling event candidates taking into consideration mobility and geographic constraints. We obtained a heat map of recharging events as shown in Fig.2 and Fig 3.

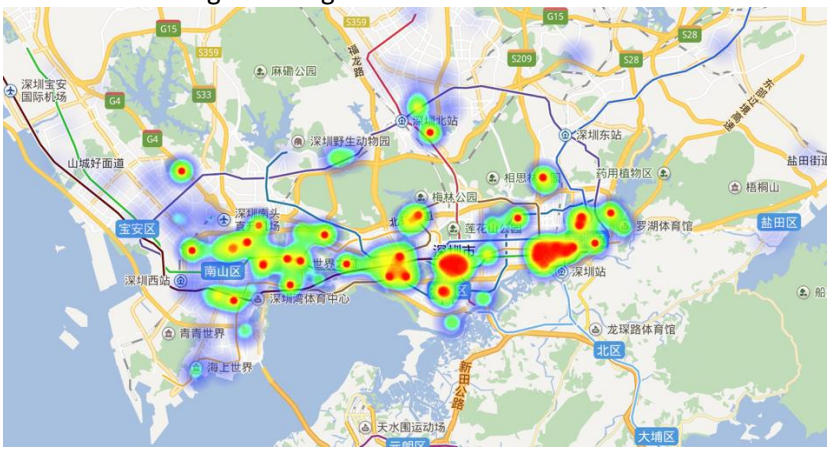
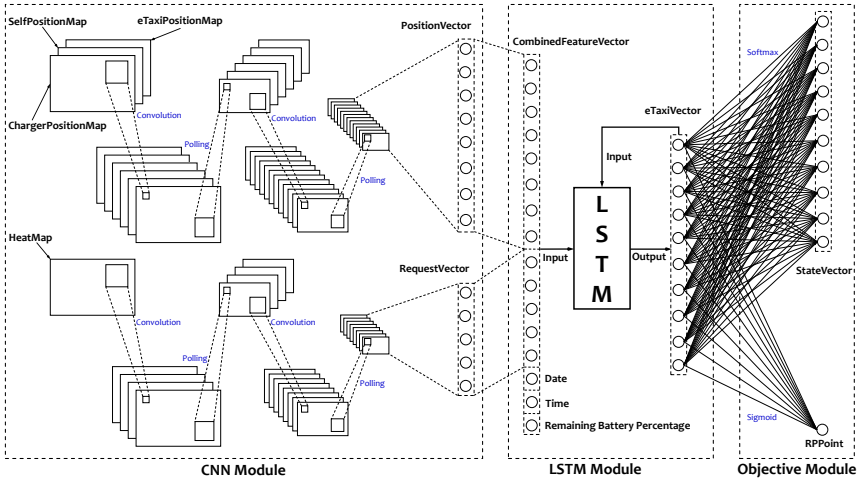


Fig.2. Heat Map of Recharging Events in Shen Zhen

Fig.3. Heat Map of Recharging Events in specific area

From Fig.2 and Fig.3, we find out there exist the huge unbalanced utilization

	among charging station. Moreover, we have also collected 150000 pick-up events per day from raw trajectories of traditional taxis.
Impacts/Benefits of Implementation (actual, not anticipated)	We will use the results of all these above data preprocessing and recharging event detection as input of our deep learning model. By using Baidu API, the revised GPS trajectories of eTaxis and position of charging station can be input of position map. The heat map of recharging events and pick-up events can be input of HeatMap. Our proposed deep learning model are shown in Fig.4  Fig.4. Deep learning Model
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