Investigating the Impact of Extreme Weather on Mobility Behavior with RP Data

Master‘s Thesis of Dingan Yan

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Research Background, Significance, and Aims

The occurrence of extreme weather events poses great challenges to urban planning and development authorities, especially in terms of transportation. Mobility behavior is a concept with a wide range, including choice of travel mode, travel distance, route choice, frequency and length of trips, and the purposes and reasons for traveling. For policy and decision-makers, understanding people's mobility behavior in response to extreme weather situations can help to build transportation systems that are more resilient to risk and friendly to different groups of people in society, and develop traffic management schemes that maximize efficiency. In this study, we aim to analyze the mechanisms of change in mobility behavior under different types of extreme weather conditions and to explore which factors contribute to the change.

Research Methodology

Our case study area: Munich metropolitan region.

Data providers: GPS travel diary dataset from Mobilität.Leben study. Daily and hourly recorded weather data from DWD(Deutscher Wetterdienst).

Methods of defining extreme weather conditions: percentile methods(low threshold: 5%, high threshold: 95%).

Target variables for assessing mobility behavior: main travel mode choice, trip purpose, trip duration.

Feature variables: hourly precipitation, hourly temperature, hourly wind speed, daily max. temperature, daily min. temperature, daily max. wind speed, travel distance, age, gender, job status, housing size, children, income.

Statistical methods: Multinomial logit (MNL) model, as shown below:

$$P(y=k|x)=\frac{e^{x\cdot\beta_k}}{\sum_{i=1}^{K}e^{x\cdot\beta_i}}$$

$P(y=k|x)$: the probability that category k is selected given features x. β_k: the vector of coefficients corresponding to category k.

Linear regression model, as shown below:

$$Y=\beta_0+\beta_1x_1+\beta_2x_2+\ldots+\beta_kx_k+\varepsilon$$

Y: target variable; $\beta_0 \sim \beta_k$: regression coefficients; $x_1 \sim x_k$: feature variables; ε: random error term.

Random forest, as shown in Figure 1:

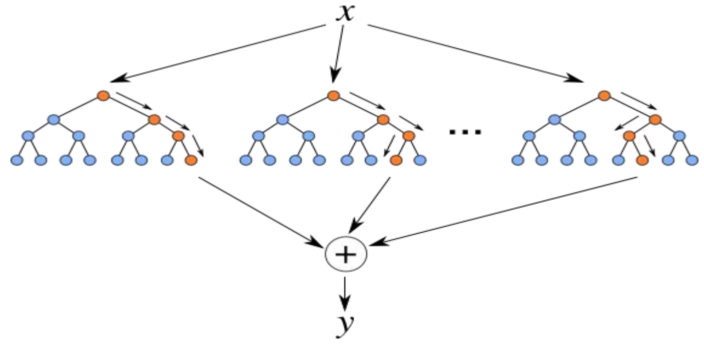

Figure 1 Random forest model

Main Findings

We classified four types of extreme weather conditions based on the percentile method:high temperature weather (hourly temperature ≥ 24.8℃), low temperature weather (hourly temperature ≤ -1.5℃), heavy precipitation weather (daily precipitation ≥ 17.84mm (only rain) or ≥ 11.08mm (only snow, snow and rain), and windy weather (hourly wind speed ≥ 5.9m/s). At the aggregate level, we found that there are significant differences in the distribution of main travel mode choice, trip purpose, and trip duration under different types of extreme weather, as shown in Figure 2.

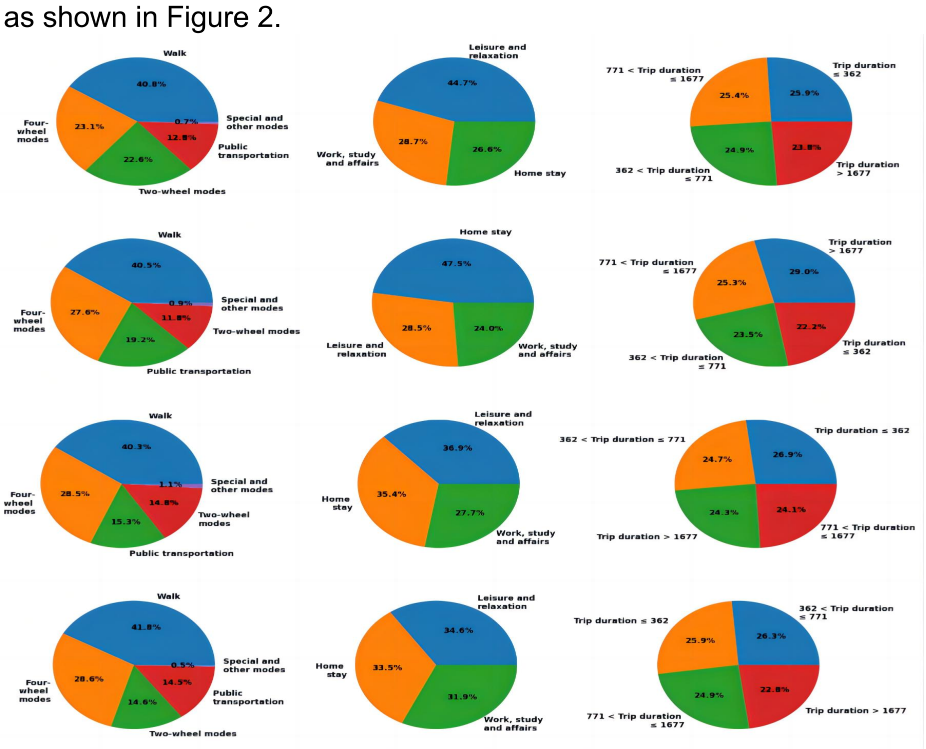

Figure 2 Share of main travel mode choice, trip purpose, and trip duration in high temperature weather, low temperature weather , heavy precipitation weather, and windy weather.

We cannot understand which factors contribute to the changes in mobility behavior specifically under extreme weather conditions only with results at aggregate level. Therefore, we also used several statistical models to conduct a more detailed analysis at the individual level, and found that:

- Public transportation becomes less popular in high temperature weather.
- People are more likely to stay at home compared to other kinds of trip purposes in low temperature weather.
- People tend to spend more time for their trips in heavy precipitation weather if they travel mainly by four-wheel modes (Car, E-Car, Carsharing, TaxiUber) or public transportation.
- Compared to predicting main travel mode choice and trip duration, the disturbance of weather effect is more noticeable.

Possible Optimization Plans for Traffic Policies

Operators can reduce public transportation ticket fares for short commuting distances during hot weather. Transportation authorities can work with the IT team to advise users on transportation options and trip purposes in response to different types of extreme weather based on their personal socio-demographic information.