Using Wearable Sensor Data From Thousands of Students to Evaluate Transport Modes

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BACKGROUND 1

- Recent developments in information technologies have enabled the crowd sensing in transportation systems, which shows many advantages over traditional surveys, such as less manpower, shorter survey period, greater accuracy, resolution, etc.
- Custom-designed sensing devices were deployed in a Singapore National Science Experiment (NSE), which captured detailed and complete commuting trip information of thousands of students of different ages
- The large, real-world NSE data set provides a powerful approach for us to examine and refine current understanding of transportation mode choices, which is critical for transportation system planning and design.

OBJECTIVE 2

- To analyze crowd-sensed data of people's commuting routes to answer three key questions in urban transportation choices:
  - Is use of private car necessarily faster than public transportation?
  - Do people living close to public transportation infrastructure prefer to use it?
  - Do people tend to choose routes that minimize walking distance even if it increases their overall travel distance?

METHOD 3

3.1. Data Collection

- This work uses data collected from National Science Experiment (NSE) using specially designed, low-cost sensing device "SENSg", which integrates multiple sensors for environment and mobility detection, including accelerometer, gyroscope, magnetometer, light intensity, sound pressure, relative humidity, temperature, pressure and Wi-Fi scanner. Wi-Fi signals are used for localization.
- Students from Primary, Secondary and Junior Colleges in Singapore volunteered to participate in a one-week data collection campaign, each carrying one "SENSg" device. In 2015, we had 43,140 students involved and collected more than 500,000 km of travel data. All data is anonymous and securely handled.

Fig. 1. "SENSg" sensing device examples

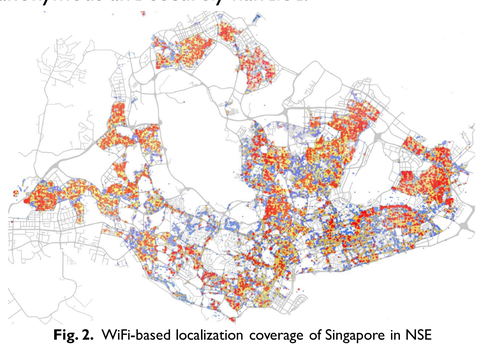
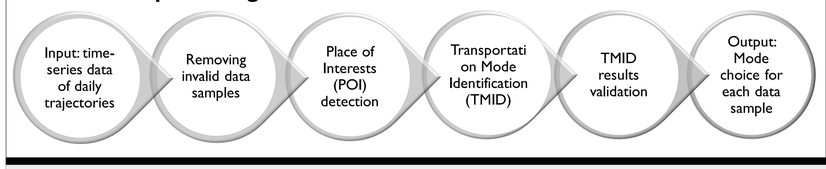
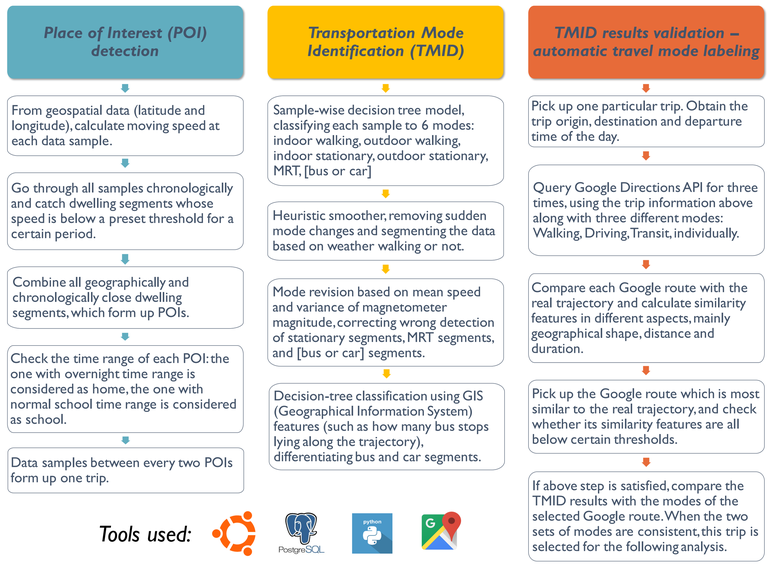


Fig. 2. WiFi-based localization coverage of Singapore in NSE

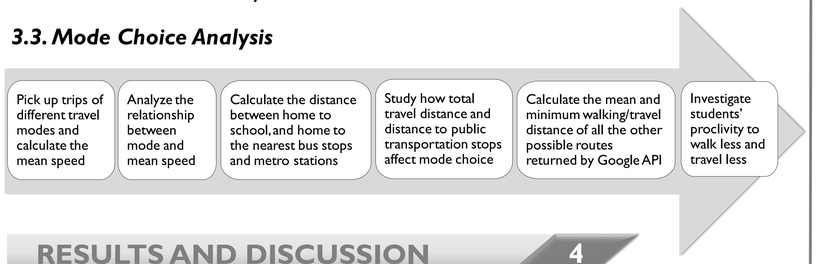
3.2. Data Preprocessing





- Morning commutes from home to school are the only travel considered due to variability introduced by students participating in a range of after-school activities
- Due to a lack of comprehensive ground truth data from Google directions queries, after data preprocessing, a subset of 1,335 students' commuting data is selected for further analysis.

3.3. Mode Choice Analysis



RESULTS AND DISCUSSION 4

4.1. Relationship Between Mode and Mean Speed

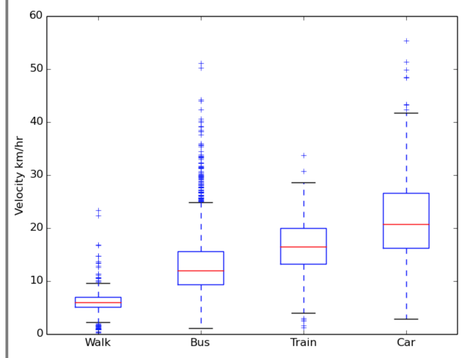


Fig. 3. The box/whisker plot of median speed of different travel modes shows that the walking, bus, train and car median speeds are 6.9, 13.0, 16.4, and 22.2 km/hr respectively. The median speed of car trips are only 6 to 9 km/hr faster than those taken by bus and train respectively, even though the public mode speeds include waiting and transfer times. This suggests that traveling by private vehicle in Singapore during morning commutes is not substantially faster than using public transportation.

4.2. Travel Distance and Transport Mode

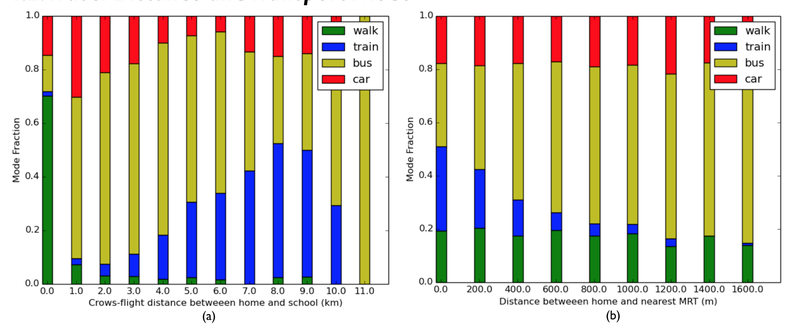


Fig. 4. Figure (a) shows that the farther someone lives from school, the more likely they are to take a train up to a distance of 8km, then bus regains mode share. Figure (b) shows that as distance between school and the nearest metro increases, there is a sharp decrease in the likelihood that a student will travel via train.

4.3. Sensitivity Analysis

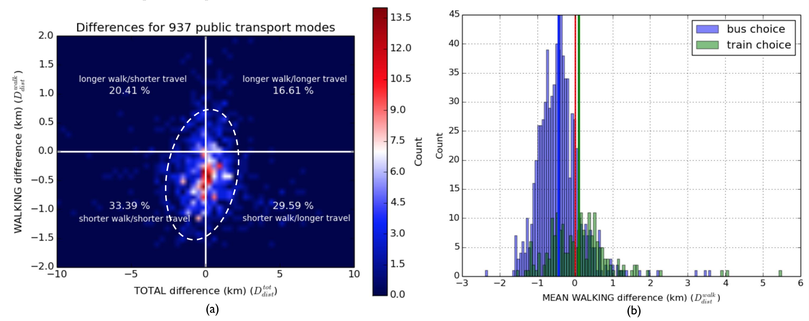


Fig. 5. The ratios in figure (a) show that 63% of students walk a shorter distance than Google predicted, 29% walked a shorter distance but traveled longer, indicating that students are likely prioritizing factors beyond travel distance in their decisions. The histogram in figure (b) shows that students who chose to travel by bus walked an average of 440m less than the mean of the walking distances in routes suggested by Google, and those who traveled by train walked an average of 90m more. This 530m difference is statistically significant.

CONCLUSIONS 5

We investigated students' travel mode choice decisions in Singapore through a data-driven approach and reach the following conclusions:

- The mean travel speed of students using public and private modes of transportation are separated by less than 10km/hr, highlighting that the choice to travel by car in Singapore is likely a factor of the availability of this mode, as well as the comfort, convenience, and other features.
- The total travel distance shows impact on students' mode choice. Proximity to metro stations does predicate a tendency to travel by train, while proximity to bus stops does not guarantee an increase of bus adoption.
- Students tend to choose trips which minimize walking distance at the expense of greater overall travel distance.

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