Advanced Computer Graphics
CS 525M: Mobile Social Networking

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Bus arrival prediction system

How long to wait for buses???

- For most city transport travelers, bus arrival time is primary information.

- Schedule of a bus may be delayed due to many unpredictable factors (traffic jam, weather, etc).

- The accurate arrival time of next bus will mitigate travelers’ anxiety and improve their experience on the road.
Related work

- **Phone-based transit tracking**
  Automatic system for low cost, real-time transit tracking, mapping and arrival time prediction using GPS collected by personal smartphones.

- **Celltower sequence matching**
  Comprehensive set of APIs with low GPS usage, high efficiency, robustness; new data structure is presented for mobile application development.

- **Participatory sensing**
  Many recent works develop participatory platforms for people-centric mobile computing applications (Micro-blog, SoundSense, SurroundSence, etc).
A novel bus arrival time prediction system based on crowd-participatory sensing.

- **Sharing users**
  information collection to build database

- **Querying users**
  Request arrival time of interested route

- **Backend server**
  Data processing & Arrival time prediction

*Figure 2: System architecture*
Bus detection : Am I on Bus?

As aforementioned, database is built by sharing users. Information to verify whether sharing users are on a public transit bus is needed.

- **Audio detection**:
  using audio frequency analysis (128pt FFT) for IC reader beep.

- **Accelerometer detection**:
  measure acceleration to figure out whether users on the train or bus.

Figure 8: Accelerometer readings on rapid train and bus.
Bus classification

Sharing users’ mobile phone samples a sequence of celltower IDs and reports the information to the backend server

- **Celltower sequence matching**
  Received celltower sequences are used for matching with stored sequences

- **Celltower sequence concatenation**
  For more accurate route classification, several sequences from different mobile phones on the same bus are concatenated

Table 1: Celltower sequence matching

<table>
<thead>
<tr>
<th>Database seq.</th>
<th>1 2 4 7 8 4 5 9 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uploaded seq.</td>
<td>7 8 4 5</td>
</tr>
<tr>
<td>Matched seq.</td>
<td>7 8 4 5</td>
</tr>
</tbody>
</table>

Figure 13: Celltower sequence concatenation
Arrival time prediction

Arrival time of the bus at queried stop is estimated as:

\[ T = T_2 - t_2 + T_3 + t_{bs} \]

In general,

\[ T = \sum_{i=k}^{q-1} T_i - t_k + t_q \]

where \( T_i \) is the time for full block of cell tower; \( t_k \) is time spent in current block; \( t_q \) is time cost in last block.
Performance of system

Bus detection accuracy:

Overall 95% within 3m from IC reader.

Bus vs. MRT train classification:

Round 90% at different time points

Bus classification accuracy

Round 90% (highest 96%, lowest 87%) accuracy for different 4 routes
Performance of arrival time prediction

(a) shows CDF of 4 routes, it indicates mean error round 80 seconds

(b) shows mean errors of 4 routes along with distance, it indicates mean error increase when distance increases.
Conclusion

- The crowd-participated based system efficiently utilizes lightweight onboard sensors of cell phones, to predict the bus arrival time for users.

- Over a 7-week experiment in Singapore, the evaluation demonstrate that the system can accurately predict the bus arrival time. (98% detection accuracy, arrival time error around 80 seconds)
Discussion and future work

- Number of celltowers a user could capture on a bus influences the bus classification accuracy
  
  *WiFi points along the route might complement celltower ID*

- First few bus stops
  
  *Only using history data to generate a prediction arrival time*

- Overlapped routes at downtown or major transit centers
  
  *Challenging...*
References