Personal Intersection Speed Advisory System (PISAS)

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Motivation

Provide individual drivers with safe and efficient speed advisory information at intersections by utilizing real-time traffic and signal status through existing communications infrastructure.
Background

- The pilot test of a personal signal assistant application has been conducted in Germany under pre-timed control system.
- The application is only available with high-end vehicle models equipped with a proper opt-in device.
- NJIT research team developed a mobile phone-based PISAS application to encourage more participants.
Overall System Architecture

- **PISAS Mobile App**
  - Vehicular Information (Position, Speed, etc.)
  - Signal Information (Cycle Time, Status, etc.)

- **GPS**

- **NJIT PISAS Database**
  - Signal Status
  - (3G/4G/LTE)

- **NJDOT Arterial Management Center**
  - Signal Status
  - (NTCIP)

- **Intersection Signal Unit**

- **In-vehicle PISAS Display**
  - Advisory Speed
Speed Advisory Algorithm

- **End of Green**
- **End of Red**

**Calculate Advisory Speed (Red Interval)**
- Min Speed ~ Speed Limit
- Min Speed ~ Max Speed
- Speed Change Not Acceptable

**Calculate Advisory Speed (Green Interval)**
- Min Speed ~ Max Speed
- Min Speed ~ Speed Limit
End of Green/Red Determination

- The corridor consists of fully actuated intersections
- End of Green/Red may vary and it is not fixed
- Probabilistic approach combined with history data used for prediction

![Graph showing End of Green/Red Determination](chart.png)

- 100% Green Probability
- End of Green with 100% Probability
- 100% Red Probability
- End of Red with 80% probability
PISAS Mobile Application

- Intersection Name
- Signal Status
- Remaining Distance
- MIN Advisory Speed
- MAX Advisory Speed
## Pilot Test Corridor: US-1 (Green St. – Plainfield Ave.)

<table>
<thead>
<tr>
<th>Intersection ID Number</th>
<th>Major Street</th>
<th>Minor Street</th>
<th>Milepost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1401</td>
<td>US 1</td>
<td>Green St</td>
<td>35.69</td>
</tr>
<tr>
<td>1402</td>
<td>US 1</td>
<td>Gill Ln</td>
<td>35.10</td>
</tr>
<tr>
<td>1403</td>
<td>US 1</td>
<td>Ford Ave</td>
<td>34.24</td>
</tr>
<tr>
<td>1404</td>
<td>US 1</td>
<td>Parsonage</td>
<td>33.64</td>
</tr>
<tr>
<td>1405</td>
<td>US 1</td>
<td>Grandview Ave</td>
<td>33.07</td>
</tr>
<tr>
<td>1406</td>
<td>US 1</td>
<td>Prince St</td>
<td>31.48</td>
</tr>
<tr>
<td>1407</td>
<td>US 1</td>
<td>Forest Haven Blvd</td>
<td>31.10</td>
</tr>
<tr>
<td>1408</td>
<td>US 1</td>
<td>Old Post Rd North</td>
<td>30.54</td>
</tr>
<tr>
<td>1409</td>
<td>US 1</td>
<td>Old Post Rd South</td>
<td>29.88</td>
</tr>
<tr>
<td>1410</td>
<td>US 1</td>
<td>Wooding Ave</td>
<td>29.52</td>
</tr>
<tr>
<td>1411</td>
<td>US 1</td>
<td>Plainfield Av</td>
<td>29.06</td>
</tr>
</tbody>
</table>
## Evaluation Results

<table>
<thead>
<tr>
<th>Evaluation Period</th>
<th>8 AM-10AM</th>
<th>1PM-5PM</th>
<th>10 PM-12AM</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Type</strong></td>
<td>W/ PISAS</td>
<td>W/ PISAS</td>
<td>W/ PISAS</td>
<td>W/O PISAS</td>
</tr>
<tr>
<td><strong>Average Travel Time (min)</strong></td>
<td>12</td>
<td>20</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td><strong>Number of runs</strong></td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Travel Time Saving (min)</strong></td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>6.4</td>
</tr>
</tbody>
</table>
Results

Average Travel Time W/O PISAS

20 Min

Average Travel Time W/ PISAS

12 Min

17 Min

10 Min

13 Min

9 Min

October 26, 2015 - INRIX

October 26, 2015 5th and 95th percentile - INRIX

October 26, 2015 25th and 75th percentile - INRIX
Concluding Remarks

- On the 6.5-mile test corridor, 6.4 minutes of average travel time savings were recorded.

- Differences between PISAS and unequipped vehicle were more obvious during AM and off-peak hours.

- During peak-hours the vehicle is often forced to follow prevailing speed maintained by the traffic.
Concluding Remarks

- PISAS is a DSRC-free V2I Connected Vehicles Application that requires no additional roadside equipment to obtain advisory speed.
- PISAS is designed to exploit commercial cellular network service (i.e., 3G and 4G-LTE).
- PISAS system can be easily plugged into existing traffic control management system to capture real-time traffic signal data.
- PISAS enables rapid implementation without significant additional cost.
Future Research

- Evaluate PISAS using various performance measures to address:
  - Effectiveness of the PISAS application in improving mobility and environmental performances
  - Quality of wireless communications (e.g., communication delay, packet drop).
- Expand test corridor to implement PISAS field test
- Develop an interface enabling direct connection from a traffic controller to a PISAS device
Questions
Advisory Speed Flowchart

R: Target Distance to trigger (e.g., 200 m)  
X: Distance to the intersection (unit: meter)  
v: Current vehicle speed (unit: km/h)  
ss: Current signal controller clock (unit: sec)  
GreenEnd: End time of Green signal (unit: sec)  
RedEnd: End time of Red signal (unit: sec)  
Amber: Yellow time (unit: sec)  
rg: remaining green time (rg = GreenEnd+Amber-ss) (unit: sec)  
rr: remaining red time (rr = RedEnd-ss) (unit: sec)  
SigSTA = Current Signal Status (Green:0, Red: 1, Yellow: 2)  
a: Estimated Acceleration/Deceleration Rate (unit: m/sec^2)  
av: Advisory Speed (m/sec)  
MaxSpeed : Max Speed for Control (e.g., Speed Limit)  
MinSpeed : Min Speed for Control (e.g., 30 km/h)

1. Start
2. Calculate: X
3. X < R
   - Yes: Get SigSTA
   - No: Add
4. Red or Green
5. rr = RedEnd-ss  
a = 2*(v^2-rrv)/(rr^2)  
6. a >= -3.0 and a < 3.0
   - Yes: av = v+a*rr
   - No: Add
7. av > MaxSpeed
   - Yes: av = MaxSpeed
   - No: Add
8. Message Display
   - Advisory Speed Range: MinSpeed ~ MaxSpeed
   - Prepare To Stop
9. Message Display
   - Advisory Speed Range: MinSpeed ~ av
10. Message Display
    - Prepare To Stop
    - Maintain Speed Limit