Big Data in Automotive Applications: Cloud Computing Based Velocity Profile Generation for Minimum Fuel Consumption

Giorgio Rizzoni, Ümit Özgüner, Simona Onori, Jim Wollaeger, Adarsh Kumar, Pardis Khayyer, Engin Ozatay
The Ohio State University
Center for Automotive Research
Department of Electrical and Computer Engineering
Department of Mechanical and Aerospace Engineering
• Introduction

The Google Prediction API accesses Google's machine-learning algorithms to analyze historic data and predict likely destinations.

Driver: Yes.

Car: Good morning, are you going to work?

Car: Your vehicle performance has been optimized for your trip.

Powertrain Optimization = improved energy efficiency and use
1. Data Communication for Driver Convenience (Consumer information, Parking Availability, Geographical Data)

2. **Energy management and optimization**

3. High Priority Safety Data (Emergency situations, Hazards)

4. Real-time, time critical (collision avoidance)

5. Traffic Management Data (Traffic Congestion and Road Closures)

6. Auto Industry Customer Service Data (Warranty Data, Diagnosis and Parts Failure)

7. …
1. Data Communication for Driver Convenience

- Consumer information Data
- Parking Availability Data
- Geographical Data

http://ebiquity.umbc.edu/blogger/2010/07/09/google-open-spot-android-app-finds-parking/
2. Fuel consumption optimization
3. Data Communication for Safety and Collaborative Driving

- Testing autonomous and semi-autonomous cars sharing information in Columbus.

- Driving 3 autonomous trucks in Japan.

- A collaborative driving exercise in Holland.
4. Time critical data – collision avoidance
Our vision of the “connected vehicle traffic” of the future where many layers of information is transmitted on demand and extensive measured data about the environment is shared.
Hierarchy of data transmission and sharing
Cloud Computing Based Velocity Profile Generation for Minimum Fuel Consumption

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Dimitar Filev, John Michelini
Ford Motor Company
Research and Advanced Engineering
Fuel consumption optimization – background and methodology
Objective: Move the vehicle from position A to B minimizing fuel consumption over the trip.

Process: Build a velocity profile based upon the geometry and speed limits of the road stored in large databases.

To find the optimal solution to move the vehicle from position A to B, a vehicle simulator is used to solve a *dynamic programming* problem.
Dynamic Programming Optimization

Minimize energy consumption over a known route, by prescribing the instantaneous velocity of the vehicle.
Siulated Driving Scenario A

Highway-Urban Driving profile composed of 2 highway segments followed by urban and highway segments (6km, 1.25km, 4km and 7.35km, respectively) with non-zero road grade.

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Additional Fuel Consumed (relative to optimal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Poke</td>
<td>+ 17.5 %</td>
</tr>
<tr>
<td>Average Profile</td>
<td>+ 23.2 %</td>
</tr>
<tr>
<td>Lead Foot</td>
<td>+ 27.1 %</td>
</tr>
</tbody>
</table>
Simulated Driving Scenario B

Actual driving profile with real grade data. It is composed of an 18.8km highway segment followed by 8.6km urban segment with multiple stops events and road elevation.

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Additional Fuel Consumed</th>
<th>Trip Duration (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal Profile</td>
<td>-</td>
<td>1578</td>
</tr>
<tr>
<td>Slow Poke</td>
<td>+ 8.2 %</td>
<td>2026</td>
</tr>
<tr>
<td>Average Profile</td>
<td>+ 10.2 %</td>
<td>1428</td>
</tr>
<tr>
<td>Lead Foot</td>
<td>+ 29.2 %</td>
<td>1132</td>
</tr>
<tr>
<td>Actual Driving</td>
<td>+ 23.9 %</td>
<td>1462</td>
</tr>
</tbody>
</table>
• Vehicle Implementation
Remote Servers
(Off-line Optimization)
Vehicle equipped with:
- Laptop
- Small Display
- GPS Receiver
- CAN-to-USB Dongle

OSU GIS Server

OSU Optimization Server

Google Maps

Wireless Internet Provider
OSU ArcGIS Server

• GIS: Geographic Information Systems
• ArcGIS software is licensed and set up on a server @ CAR
  • Geographic information from:
    • USGS (United States Geological Survey)-Provided DEM
data of the entire US
      • 3 meter resolution of Ohio
      • 10 meter resolution of Continental US
  • Total database size of elevation data: 700 GB
Sample Elevation Data loaded and published on OSU Servers
Driver Interface

Colors Change Based on Driver behavior:

**RED:** Going too fast-SLOW down

**WHITE:** Within Target Range

**GREEN:** Going too slow-SPEED up
1. System was given the waypoints A, B, and C
2. Google Routing algorithm decides upon a route and transmits coordinates to OSU servers over the internet.
3. Communicate with OSU GIS server and get elevations.
4. Run Optimization

Total Trip Distance ≈ 2.2 Miles

This route will be used for
Optimal Profile

Profile was optimized using new Vehicle Model with a velocity resolution = 2 MPH. Predicted MPG: 24.5
Conclusion

- Velocity planning: Through the solution of an optimization problem, we have generated an optimal velocity profile to minimize vehicle fuel consumption through cloud-based optimization.
- Future work includes implementing real-time road traffic information with the cloud-based optimization to recalculate the optimal velocity profile in real-time in response to external traffic disturbances.
- One of the key questions that will be addressed in future research is the scalability of this concept to large numbers of vehicles, and the implications with regard to wireless communications, computing and real-time requirements.
Thank you for your kind attention!

Questions?

http://car.osu.edu