DriveSense: Contextual Handling of Large-scale Route Map Data for the Automobile

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"Big data isn't about size but about complexity, purpose, community, scale."
- Francine Berman
Automobile- a producer of big data

- Speed
- GPS
- Engine
- Fuel level
- Tire pressure

OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signaling protocols available, and the messaging format.
Self-driving cars

- Self-driving cars will produce over 1GB of data per second
- Combination of on-board sensors, audio, video, laser-based radar for object detection
- Effectively managing and conveying this information to the driver is crucial

Source: Self-driving cars could create 1GB of data a second
http://www.computerworld.com/s/article/9240992/Self_driving_cars_could_create_1GB_of_data_a_second
Mobile phone as a persona
Navigation systems
Motivation

Simplification

Landmarks


Research contributions

• Handling big data overload by rendering the maps with differential levels of detail based on contextual importance.
  ▪ Fetching appropriate routing information using vehicle sensor data
  ▪ Personalized routing based on
    ▪ Familiarity
    ▪ Speed
    ▪ Gas level
    ▪ Time of day (lunch time)
Video
System overview
Map generalization

Exaggeration

Elimination

Typification

Outline Simplification
Map browsing
Server synchronization

- Syncs asynchronously
- Retrieves sensor information from OBD2
- Raw input is converted into a suitable form for routing and mapping
Interface

Search

History

Dashboard
Interface
Spatial detail

The spatial detail indicates the density of vector strokes per unit area.

0.833754

0.558025

0.231496
Retrieve importance weights based on context and map semantics

Compute spatial detail budget

(Spatial detail budget) < (Object’s spatial detail ?)

Simplify object until spatial detail is balanced

Exaggerate object until spatial detail is balanced

Input Map

Apply Exaggeration

Apply Simplification
Route familiarity

The GPS trajectories are matched with geometry instances in the database.

Route familiarity

Visualization

SQL query

```sql
CREATE VIEW known_roads AS
(SELECT DISTINCT geom
FROM ways
JOIN usage_data ON
usage_data.gid = ways.gid
AND usage_data.user_id=42);
```
Route familiarity

Blue – Shortest path
Red – Familiarity-based path
Speed variance
User evaluation

7 subjects drove to an unfamiliar destination using a GPS and DriveSense.

Qualitative survey (1=low confidence/ease, 5 = high confidence/ease of use)
Measuring visual clutter

Feature congestion = 7.4626

Feature congestion = 5.2772

DriveSense Representation Evaluation

FC: Feature congestion
SE: Sub-band Entropy – wavelet based decomposition to compute visual clutter
Future work

• Longer user evaluation with subjects to evaluate familiarity-based routing
• New opportunities for leveraging other technology such as voice recognition and gaze detection along with graphics
• New metrics and practices for evaluating graphics + user experience on the roads
Thanks!
Computational Measure of Spatial Detail

Neighborhood Gray-Tone Difference Matrix (NGTDM). The i-th entry in the NGTDM is defined as:

\[
s(i) = \begin{cases} 
\sum |i - \bar{A}_i|, & \forall i \in N, \text{ if } N_i \neq 0 \\
0, & \text{otherwise}
\end{cases}
\]  

(1)

where \(N_i\) is the set of all pixels having gray tone \(i\).

Using NGTDM, spatial detail is given by:

\[
\text{Spatial detail} = \frac{\sum_{i=0}^{G_h} p_i s(i)}{\sum_{i=0}^{G_h} \sum_{j=0}^{G_h} |ip_i - jp_j|} 
\]

(2)

where \(G_h\) is the highest gray-tone value present in the image. The numerator is a measure of the spatial rate of change in intensity, while the denominator is a summation of the magnitude of differences between luminance values.