GIS Web-based PAVEment MONitoring System for Civil Infrastructure Roadways

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7/22/2015

ESRI User Conference
Outline

• Introduction
  o End-2-End Pavement Inspection Technology

• PAVEment MONitoring system
  o Design and Architecture
  o Features and Layers
  o Live Demo

• Current work
Data Collection Technology

Acoustic Sensors
Tire-induced vibrations and sound waves to determine surface texture, roughness and overall condition.

Optical System
Capturing surface defects for visual confirmation of results & automatic analysis of cracks types and severity.

Electromagnetic Sensors
Surface radars to determine road profile, rutting depth & surface features (potholes, water, manhole).
Subsurface radars to determine pavement layers thicknesses and electromagnetic properties.
Outputs of each survey

Positioning Data

- GPS Location
- Collected every one second
- Only stream with geo-spatial columns
 Outputs of each survey

Sensors’ Raw Data
- 50 kHz (50,000 data points per second)
- stored every 30 seconds as binary files
- Time synchronized with Positioning Data
Outputs of each survey

Video Images
- Collected every 1 meter
- Distance triggered
**Processed Outputs of each survey**

### Processed Data

- Processed from individual sensors (microphone, tire pressure sensor, mm-wave radar, camera)

- Predicting Pavement-related features
  - Roughness (IRI)
  - Texture (MTD)
  - Crack Types and Density
  - Others

- Time synchronized with Positioning Data
Fused Outputs of each survey

Fused Data

- Processed from multiple sensors
- Predicting Pavement-related features and creating noise-removal algorithms
  - Pavement Condition (PCI) Prediction
  - Feature Identification
  - Noise-removal algorithms

500 GB to 1 TB per survey day
Big Data Handling

• Challenges
  – Proper Geo-referencing data of various modalities
    • Source of data is not stationary
  – Huge amounts of data (oTB) in each survey
    • Demands automation
  – Road features in increments as small as 1 m
  – Time-triggered and distance-triggered datasets
  – Dealing with noise in the data
    • Performing data validation routines to identify outliers
**Design and Architecture**

**File Server:**
- After each survey, raw data are uploaded to the file server then processed.

**GIS Server:**
- **Data intake scripts:** Feeds streams into the work station
- **Fusion scripts:** Performs Data Fusion, e.g. to calculate PCI or do noise-removal.
- **GIS software:** Geo-references streams and does spatial analysis
- **Oracle database:** Stores data streams from GIS software
- **Web adapter:** Pushes data to the web
- **Flex API:** Consumes services on the GIS server
Data Layers

Vector data

- **Point**: GPS Locations, Road Features (potholes, manholes, etc.), Image pop-ups (populated for every 1 m of road)

- **Polyline**: Pavement ratings (roughness, texture, overall)
  - Segmented intersection to intersection and custom intervals

Image data

- **Mosaic layers**
<table>
<thead>
<tr>
<th>Layer</th>
<th>Feature</th>
<th>Shape</th>
<th>Segments</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>FUSED</td>
<td>Pavement Condition Index (PCI)</td>
<td>Polyline</td>
<td>As small as 10 meters</td>
<td>Microphone DTPS</td>
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<tr>
<td></td>
<td>Road Features (Cracks, Patches, Potholes, Manholes)</td>
<td>Symbol</td>
<td>Where feature exists</td>
<td>Microphone DTPS mm-wave</td>
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<tr>
<td>PROCESSED</td>
<td>Mean Texture Depth (MTD)</td>
<td>Polyline</td>
<td>As small as 10 meters</td>
<td>Microphone</td>
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<td>Roughness Index (IRI)</td>
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<td>As small as 10 meters</td>
<td>DTPS</td>
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<td>Crack Density</td>
<td>Piechart</td>
<td>Where feature exists</td>
<td>Camera</td>
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<tr>
<td></td>
<td>Pavement Layer Thickness</td>
<td>3D</td>
<td>Every 1 cm</td>
<td>GPR</td>
</tr>
<tr>
<td></td>
<td>Dielectric Constant</td>
<td>3D</td>
<td>Every 1 cm</td>
<td>GPR</td>
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<tr>
<td>VIDEO</td>
<td>Mosaic Layers</td>
<td>Mosaic</td>
<td>Where feature exists</td>
<td>Camera</td>
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<td></td>
<td>Image Pop-ups</td>
<td>Point</td>
<td>Where feature exists</td>
<td>Camera</td>
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<td>Cracks Statistics</td>
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<td>Camera</td>
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<tr>
<td>POSITIONING</td>
<td>Vehicle Location</td>
<td>Point</td>
<td>Where feature exists</td>
<td>GPS</td>
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<tr>
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<td>Vehicle Path</td>
<td>Line</td>
<td>Where feature exists</td>
<td>GPS</td>
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<td>RAW</td>
<td>Raw Binary Streams</td>
<td>Point</td>
<td>Where feature exists</td>
<td>All Sensors</td>
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<td>Third-party</td>
<td>Reference PCI</td>
<td>Polyline</td>
<td>Custom streets</td>
<td>Engineering firms</td>
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<tr>
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<td>IRI of MA Highways</td>
<td>Polyline</td>
<td>Custom streets</td>
<td>MassDOT</td>
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<tr>
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<td>Traffic (AADT) and Load (ESAL)</td>
<td>Polyline</td>
<td>Custom streets</td>
<td>LTPP Database</td>
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<tr>
<td></td>
<td>Climate and Extreme Events</td>
<td>Polygon</td>
<td>Geographic Regions</td>
<td>NOAA</td>
</tr>
</tbody>
</table>
**PAVEment MONitoring System**

- **PAVEment MANagement System**
- **Web-access**
- **Mapping and Reporting**
- **Visualization**
- **Real-time Display**
- **Data Fusion**
- **Data Storage**
- **Data Creation**

**PAVEMON**

- **S1**
- **S2**
- **S3**

**Results**

**STREETSCAN**

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PAVEMENT MANAGEMENT SYSTEM

Pavement Evaluation

Budget Planning

Deterioration Model

Maintenance Suggestions & Priority Assessments

Database Configuration

Current Work

Display and analysis of subsurface data layers from StreetScan’s new air-coupled GPR arrays.