Northeastern University

STREETSCAN

GIS Web-based PAVEment MONitoring System for Civil Infrastructure Roadways

Salar Shahini Shamsabadi, Ralf Birken, and Ming Wang

7/22/2015

ESRI User Conference

Outline

- Introduction
  - End-2-End Pavement Inspection Technology
- PAVEment MONitoring system
  - Design and Architecture
  - Features and Layers
  - 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

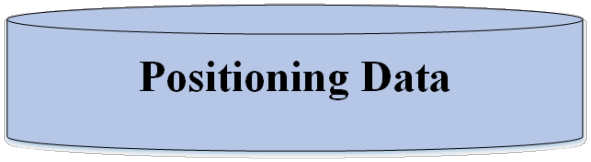
Surface radars to determine road profile, rutting depth & surface features (potholes, water, manhole).

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

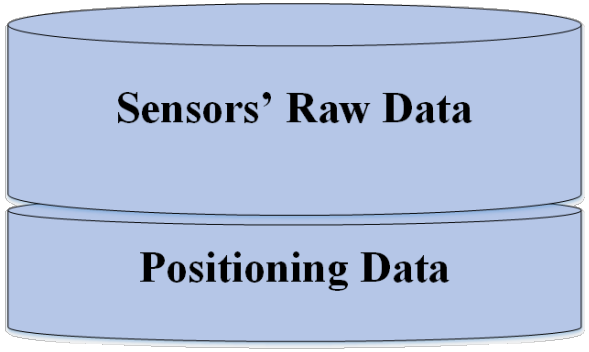
- 50 kHz (50,000 data points per second)
- stored every 30 seconds as binary files
- Time synchronized with Positioning Data

Microphone

Tire Pressure Sensor

Mm-wave Radar

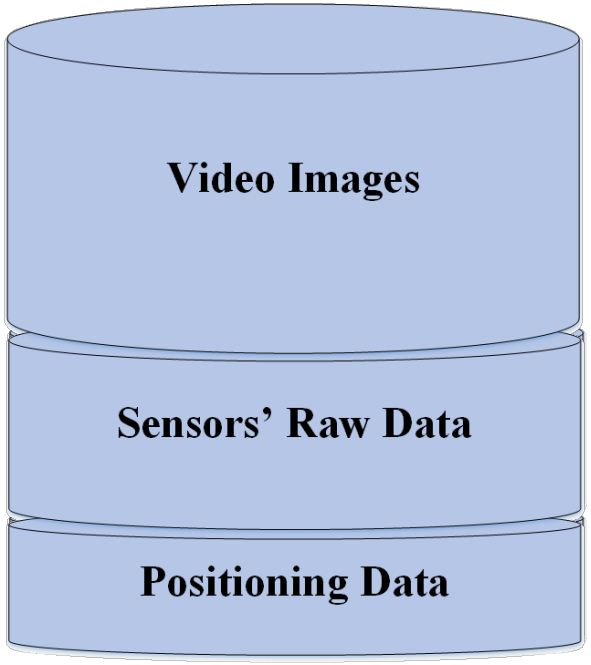
Axle-accelerometer



Outputs of each survey

Video Images

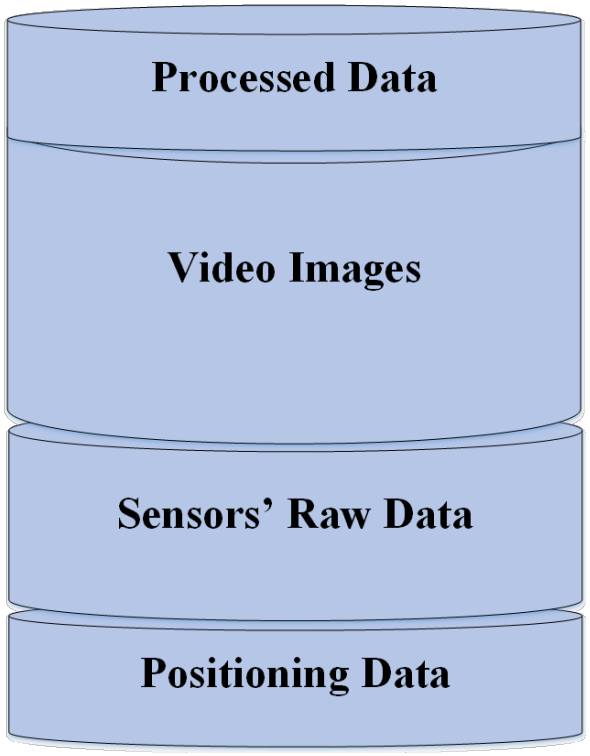
- Collected every 1 meter
- Distance triggered



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

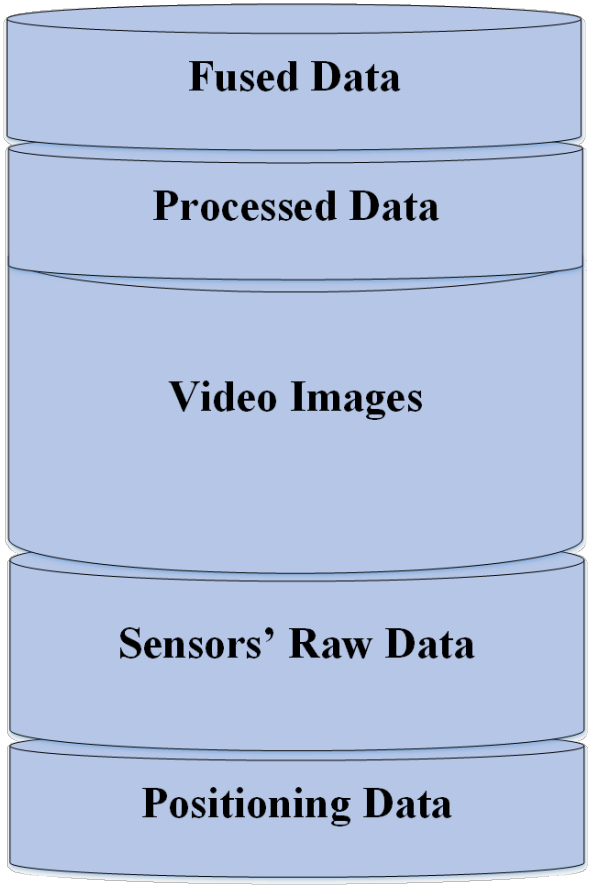


Fused Outputs of each survey

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*

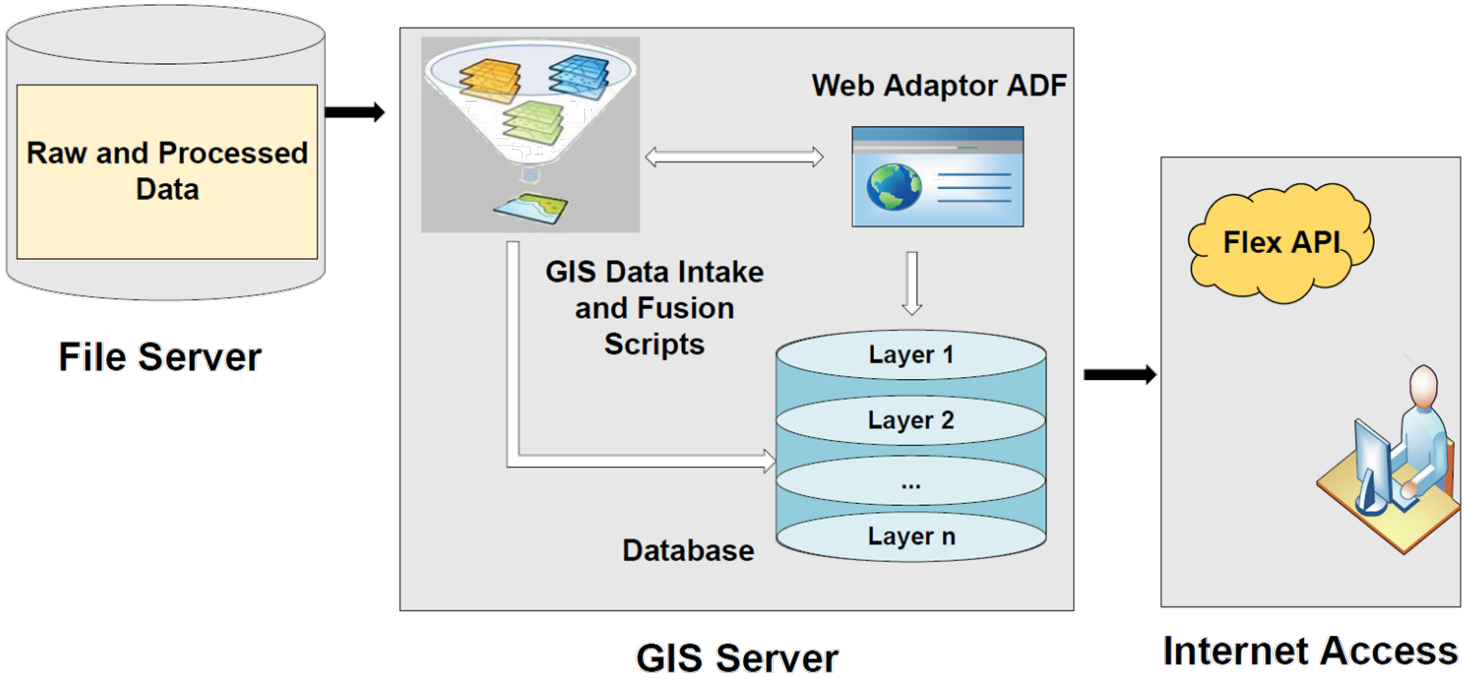
Design and Architecture

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



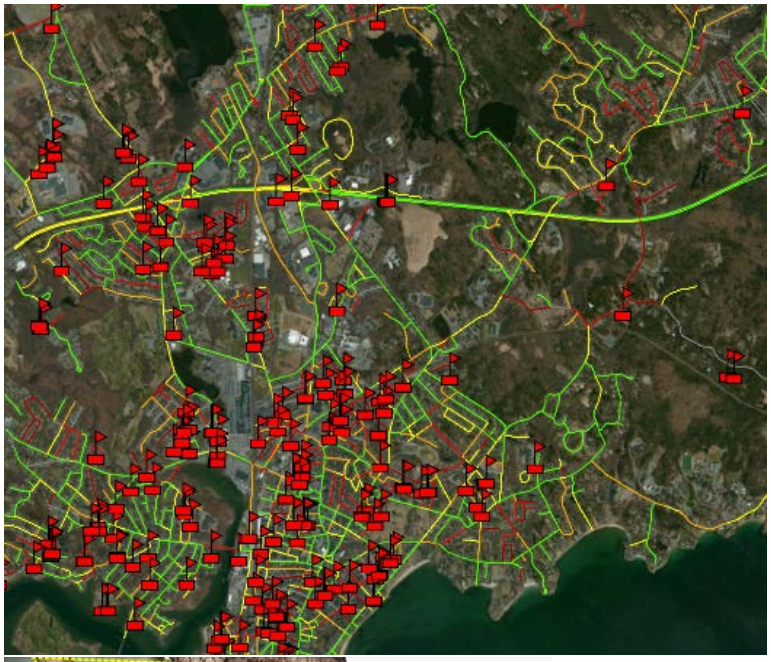
Data Layers

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**



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

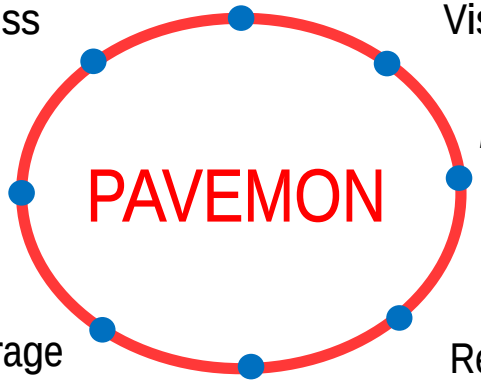
*PAVE*ment *MON*itoring System

Mapping and Reporting

Web-access

Visualization

Data Fusion



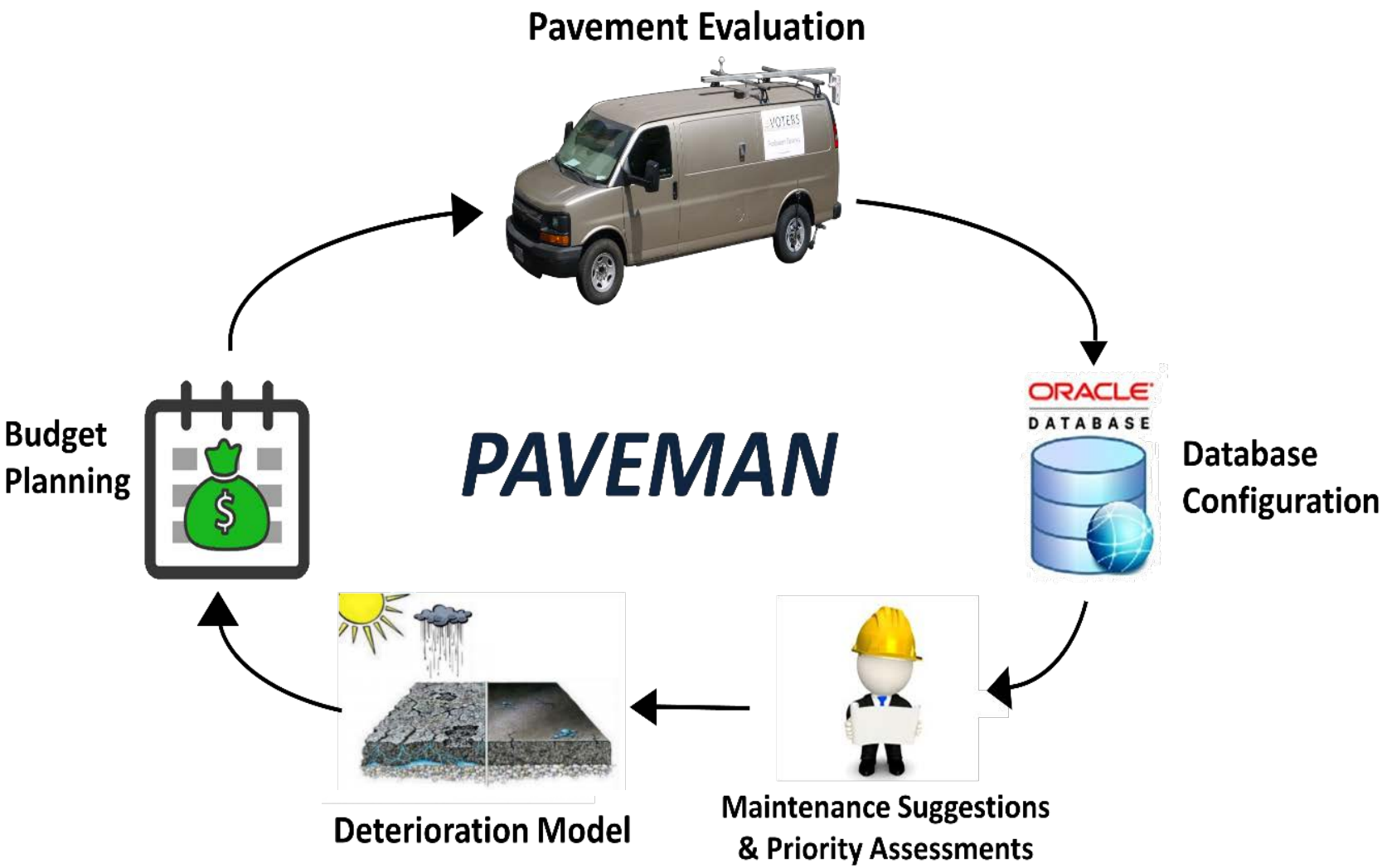
*PAVE*ment *MAN*agement System

Data Storage

Real-time Display

Data Creation

PAVEment MANagement System[1]



1. *Shahini Shamsabadi S., Aleti T., Birken R., Wang M. , 2015, "PAVEMAN: A Data Driven Customizable PAVEment MANagement System", TRB Annual Meeting, Washington, DC.*

Current Work

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