Wisdom Stone

Vision and Development of a Wireless Autonomous Pavement Sensor

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HS_DSL

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TECHNION

The Technion Israel institute of Technology

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High Speed Digital System Laboratory

Israel National Road Company

נתיבי ישראל
החברה הלאומית לתשתיות תחבורה בע"מ

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Motivation

- Measure the mechanical response of pavements:
  - Moving traffic loads
  - Different environmental conditions
- Support:
  - Health monitoring
  - Detection of catastrophic events
  - Performance prediction
  - Improving design and construction methods
  - Traffic detection and characteristics

What is Wisdom Stone?

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- Autonomous wireless sensor;
- Encapsulated in an aggregate-like casing.

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Smart Aggregate Vision

- Deployment:
  - Thousands (dust-full);
  - Random location;
  - Deployment in depths until 1.5m.
- Sensing ability at point of embedment:
  - X-Y-Z Accelerations;
  - Sound;
  - Temperature;
- Inexpensive sensor;
- Design:
  - Packa… …ion within the system;
  - …reprocessing;
  - …munication;
  - …ng software.
- Applic…ion:
  - Structural health monitoring;
  - Traffic monitoring.

Doesn't exist

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First Generation Design

- **Proof of concept**
  - Develop a model for pavement monitoring
- **Research environment**
  - Preparations for later additions
  - Local processing and remote processing
  - Lab and road working environment
- **Modular**
  - Enable replacing sensors
  - Enable alternate communication channels
  - Enable different power sources
- **Future support**
  - forward compatibility
  - Provisioning for additional HW: MODEM, GPS, moisture sensor, etc
  - Utilize low cost BOM

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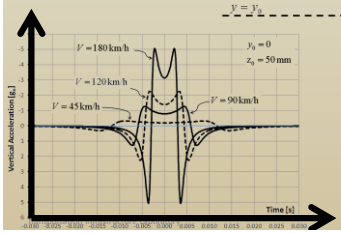
Proof of Concept – Using Accelerometer Data

- Dynamic range of accelerations
- Sampling Rate
- Initial analysis direction

?



Theoretical model

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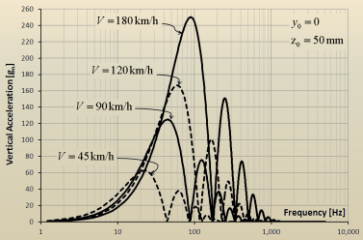
Proof of Concept – Using Accelerometer Data



Findings:

- Acceleration range 10µg to 10g
- Minimal sampling range 200Hz
- First modeling: fitting measured accelerations to computed models

Transportation Infrastructure Laboratory

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Technical Survey

- **Sensing sources**
  - Accelerometers
    - **Low cost Accelerometers**
      - 1 ~ 10$
      - 0.5 ~ 2mg resolution
      - Low power, not sensitive for handling
    - **High cost Accelerometers**
      - 1,000 ~ 2,000$
      - 10 ~ 50ug resolution
      - Sensitive for handling
  - Microphone
  - Temperature
- **Local storage**
  - EEPROM
  - SD FLASH
- **Power requirements**
  - Occasional operation
  - Lithium battery – 20Ah
  - May hold up to 5 years
- **Transmission channels**
  - 2.4Ghz: high BW, low penetration
  - 433Mhz: lower BW, higher penetration
  - 800Khz-30Mhz higher penetration, large antenna, low BW
  - Main block: humid environment
  - Debug: USB

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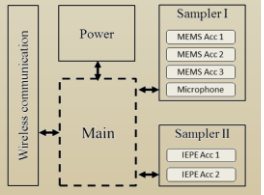
Prototype – HW and case

Long version

Short version

Main blocks diagram



Prototype - HW

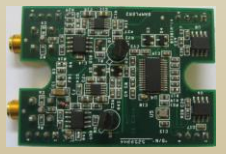
Main(down)

Main(up)

Power

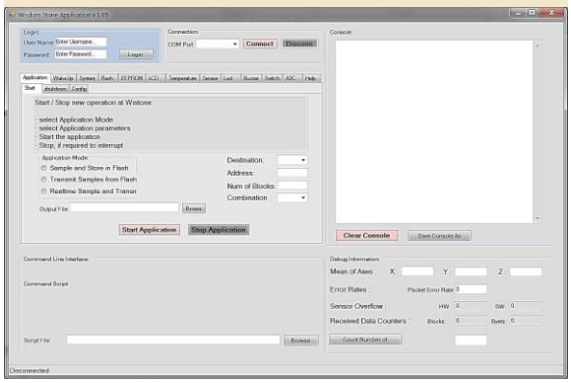
Sampler I

Communication

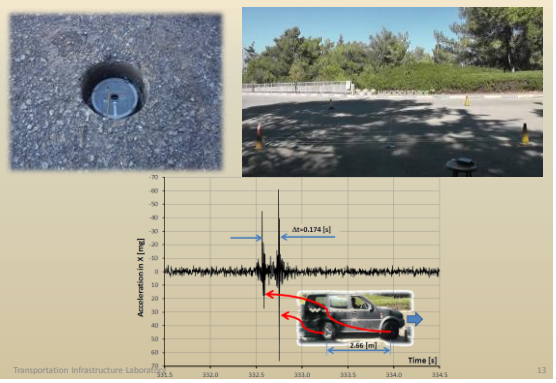


Sampler II

Graphical User interface (GUI)

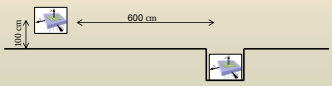


Field Experiments – Sensing Ability

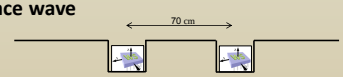


Field Experiments – Wireless Communication Range

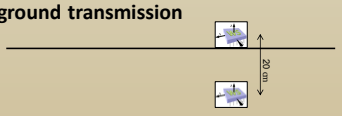
Schema 1 : broadcast in LOS



Schema 2 : surface wave

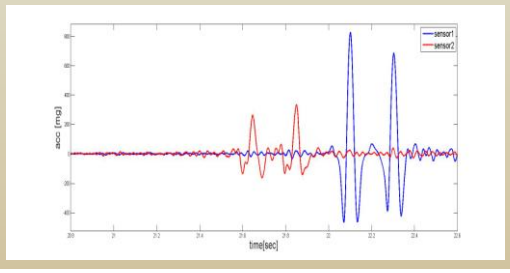


Schema 3 : underground transmission



By Product – Highly Accurate Speed Detector

- Using two wisdom stones simultaneous measurements
- DSP algorithms : matched filter and cross correlation



Future Development Directions

- Networking
  - Information relay to or from end point stones
  - Simultaneous sampling
- Remote control
  - Gathering information remotely using cellular network
  - Establish central data base
- Data analysis
  - Improve methods of data smoothing
  - Developing models for the pavement
- Wireless underground communication
  - Improve transmission range
  - Examine other transmission technologies : acoustic broadcast
- Add acoustic measurement

Research Team







Boaz

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Questions Time