Leak Detection Research and Development

SOUTHWEST RESEARCH INSTITUTE®

Maria Araujo
John Edlebeck
Topics

Machine Learning Applied to Leak Detection
Leak Detection Sensor Testing
Gas Emissions Monitoring
Application of Machine Learning to Leak Detection

SOUTHWEST RESEARCH INSTITUTE®
So What Was SwRI’s Research Goal?

- Develop a leak detection technology that is:
  - Platform Agnostic (Aerial, Ground, Stationary)
  - Low false alarm rates in a wide range of environmental and operational conditions
  - Non-intrusive, minimal to no retrofit to existing infrastructure
  - Autonomous
  - Real-time capable
  - Extensible
  - Able to detect any common pipeline fluid or gas without specific pipeline or operator-specific tuning
Smart Leak Detection (SLED) System

- A combination of optical sensor modalities
  - COTS components
  - Visible (0.4μm – 0.9μm)
  - Long-wave Infrared (7.5μm – 13μm)
Optical Sensing + Machine Learning

- Optical sensing already used in leak detection
- Addition of machine learning techniques for
  - Autonomy
  - High Reliability (low false alarm rates)
  - Machine Learning
    • Powerful techniques such as convolutional neural networks
    • Extensible and robust detection
Are There Hazardous Liquids In These Images?
Hazardous Liquids Detection and Classification by SLED

Crude Oil

Mineral Oil

Diesel

Gasoline
Are There Hazardous Liquids In These Images?
Hazardous Liquids Detection and Classification by SLED
SLED - Leak Detection Video
SLED is Extensible and can be used for...

- Different target substances
  - Gases – methane, ethylene, nitrogen

- Different sensors inputs and combinations
  - Optical sensors
  - Analog sensors
  - Fiber optics
  - Acoustic sensors
  - Etc.
SLED for Methane

- Based on SLED work and results
  - We were recently awarded a project by the DOE to develop a similar technology to detect methane leak/emissions at compressor stations and similar-type facilities
  - 18 month project started in October 2016
Next Steps for SLED

- We want to demonstrate and quantify system performance in a realistic scenario
  - Pipelines
  - Facilities
Leak Detection Sensor Testing
Technology Validation

- Areas of evaluation
  - Evaluation of performance
  - Non-leak alarm discrimination
  - Ease of implementation
  - Robustness

- Methods
  - Laboratory testing
  - Field testing
Leak Characterization

- Discharged fluid propagation
- Thermal profiles
- Plume migration
- Acoustic fields

![Image of a leak event with a spray of gasoline]

![Image of a pressure wave amplitude graph]

![Image of jet-plume transition graph]

Gasoline 100-mile Pipeline for Various Leak Rates:
- Gasoline 0.1% Leak Rate
- Gasoline 1% Leak Rate
- Gasoline 3% Leak Rate
- Gasoline 5% Leak Rate
Field Testing of Negative-Wave Systems

Pump Station

Withdrawal Location

Valve Site

45 m

21 km

41 km
Testing of DTS/DAS Systems - Large-Scale Testing

Leak Into Water

Leak Into Soil

Hydrophones and Thermocouple Locations

Fiber Cables

Final Soil Fill Level

Control Room

Actuation Panel

Camera Stand

Acoustic Float Material

Hydrophones (suspended by buoy)

Pressure Vessel
Need for Facility Field Testing

- Facility leaks responsible for:
  - 52% of all leaks\(^1\)
  - 60% of all leaks less than five (5) barrels\(^1\)

- 76% of facility leaks are less than five (5) barrels\(^1\)

- Often outside of monitored segments

- Lack of available performance data for aboveground leak detection at facilities

- Possible to accommodate many types of technologies in one test
Gas Emissions Monitoring
SwRI Emissions Monitoring

- SwRI has conducted tests on gas monitoring technologies in laboratories, field, and customer sites
- Experience with state-of-the-art instrumentation:
  - OGI
  - CRDS
  - TDLAS
SwRI Emissions Technology Areas

- Instrumentation evaluation
- Fugitive emissions testing
- Leak quantification
- Leak modeling
Methane Detectors Challenge

- Lead testing of novel low-cost sensors for continuous monitoring
- Partnership with the Environmental Defense Fund and collaboration with:
  - Eight gas companies
  - U.S. federal government
  - Three universities
  - Multiple technology companies

Questions?

Maria Araujo
(210) 522-3730
Maria.Araujo@swri.org

John Edlebeck
(210) 522-2538
John.Edlebeck@swri.org
References