Xerox Vehicle Occupancy Detection System

Xerox America’s Commercial, State and Government Transportation (ACSGT)

Xerox Innovations Group (XIG)
Xerox Research Center Webster (XRCW)

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Congestion Countermeasure: “Managed” Lanes

Traffic congestion sets US back by $87 billion/year in wasted fuel and time (2010)

Managed Lanes:
- High Occupancy Vehicle lanes (HOV)
- High Occupancy Tolling lanes (HOT)

Enforcement has Proven Difficult:
- HOV lane violation rate: up to 65%
- Manual HOV enforcement rate: <10%

“Current enforcement practices limit potential support for more HOV/HOT projects.” –McCormick Rankin Corp

HOT Lanes:
- HOV Lanes which Single Occupant Vehicles may use if they pay a toll.
- Toll is assessed with an RFID transponder.
- Use RFID transponders with Self-declaration switches
- Voluntary Compliance

High Occupancy Vehicle (HOV) and
High Occupancy Tolling (HOT)
Vehicle Occupancy Enforcement

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IBTTA History on the Subject

The Future of Tolling: ORT and the Path to Interoperability

Roadside Systems Sensing Technologies

• Viable Technologies
  – Multiband Infrared Systems
  – Infrared Systems

• Non-viable Technologies
  – Photo and Video Systems
  – Passive Microwave
  – Ultrawideband (UWB) Radar
HOV / HOT Enforcement Goals

**HOV Enforcement Goals**

• Improve current manual enforcement accuracy

*Increase from 10% → 60% to 70%

• Improves Safety for Law Enforcement

• Provide automated process for enforcement and notification

• Provide mobile enforcement capabilities

**HOT Enforcement Goals**

• Need higher accuracy for toll violation enforcement – >90% desired

• Automated Process of both Toll Violation and HOV Violation

• Provide automated process for enforcement and notification

• Provide mobile enforcement capabilities
Video-Based Detection Challenges

1. Lack of proper illumination
2. Tinted glass
3. Occlusion of Occupants
4. Pose Variation of Occupants
5. Vehicle speed, size, shape
6. Imaging Geometry varies
7. Window Composition
8. Weather condition (snow, fog, atmospheric distortion etc)
9. Use of dummies
Xerox Occupancy Detection Strategy

- Can detect front and rear seat occupancy
- Dummy Detection Possible
- Robust to blurring due to motion
- More robust to weather related noises
- High cost/potential high accuracy

- Low cost/Acceptable accuracy
- Rear seat occupancy imageable and automatically detectable
- No distinction in Dummy and Human detection

- Geometric approach

- Biometric approach

Sample Images & Face Detection Algorithm

- Passenger Face Detected: Not a Candidate Violator
- Passenger Face Not Detected And Seat Detected: Candidate Violator
Leveraging Existing Tolling Infrastructure
Active Roadway Pilot Results: Vehicle Occupancy Testing
Baltimore, MD
November 2012
Front Seat Detection Processing Steps

- Raw Captured Infrared Image
- Xerox Automatic Windshield Detection
- Cropped Windshield Sub-Image
- Xerox Automatic Passenger Detection
- Front Passenger Side Crop
- Xerox Automatic Image Enhancement
- Cropped Windshield Sub-Image
Pilot Side View Detection Performance

Statistics:

• Detection Accuracy: 94.3%
Summary: Vehicle Occupancy Detection
Public Roadway Testing

Baltimore, MD
City Road Intersection
November 12-27, 2012

2 Camera System: (1) Front Seat viewing Camera, (2) Rear Seat viewing Camera

**Front Seat:**
39,000 Images Captured, 24hrs/day
Image Quality for Human Review on >99% of Images
**Automatic Front Seat Passenger Detection Accuracy: 97.6%**

**Rear Seat:**
>3900 Image Captured, daytime only
Acceptable Image Quality for Human Review on >90% of Images
**Automatic Rear Seat Passenger Detection Accuracy: 94.3% for >1300 Images**
Driver Cell Phone Usage & Seat Belt Usage can also be Observed in Images
Next Steps:
Pilot Tests Scheduled for 2013

- Bay Area Toll Authority
- Halifax Dartmouth Bridge Commission
- Any Volunteers?