A Truck Parking Availability Notification System Based on Computer Vision

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TPAS Overview

- Motivation
- System principle of operation
- Sites deployed
- Detection performance results
- Upcoming expansion and deployments
- Operations and Maintenance Requirements
System Implementation Requirements and Scope

- Non-intrusive
- Complete 24/7 automation of direct detection of parking space status
- Accurate and scalable
- Requiring no human intervention or re-zeroing
- Cannot interfere with facility during installation or maintenance
- Develop architecture to aggregate, archive, and broadcast information to Roadside, Web, and in-cab mechanisms
Automated counting of occupied parking spaces is not a straightforward problem

- ‘Entrance/Exit ‘Trip-wire’ count detection: Small detection error bias will cause occupancy count errors to accumulate at an unacceptable rate (Martin, 2012, 2011; Gentler & Murray, 2011; Fallon & Howard, 2011)
- Count errors affected by: trailer drops, gas fill-up, vehicle classification and counting axles
• *Ingress-Egress counts may not indicate parking space availability*
Persistent Accuracy

- Accuracy = Usability

- Recent studies (ATRI) suggest drivers will ignore parking status notifications if wrong just 2 times

- Above 95% indicated by carriers and drivers to consider it useful (FHWA, ATRI)
Key Idea for Detection

• Multiple camera views reconstruct the scene in 3D.

• 3D reconstruction: Measures space occupancy directly by ‘seeing’ the vehicles present or absent in a way similar to the way people do, in 3D.

• Remains robust to problems with sharp shadows, partial occlusion, and other lighting changes that traditionally confound ‘non-3D’ image processing techniques

• No recalibration or ‘re-zeroing’.
Detection Steps

1. Multi-view PTZ HD Images Acquisition

2. 3D Reconstruction and alignment

3. 3D background removal and occupancy classification
Implemented State Sponsored Facilities

- Rest Areas accessible for East Bound traffic on Interstate 94
- All within 100 miles of Minneapolis/Saint Paul, MN

- Elm Creek
  - 15 stalls
  - Mile 215.0

- Big Spunk Lake
  - 16 stalls
  - Mile 151.7

- Enfield
  - 18 stalls
  - Mile 187.0

- Elm Creek
  - 15 stalls
  - Mile 215.0
Site Installations

- 35’ tall crank-down camera poles with up to 3 COTS PTZ cameras
- Power and communication paths from visitor building to poles
- Cellular Service for remote monitoring and real-time data transfer
- To date (May 2016) all sites in operation for 2 to 3 years
Site Installations

Indoor consumer desktop PCs, backup power, and comm hardware
Elm Creek

- Installed January 2013
Big Spunk Lake

- Installed November 2013
Enfield

- Installed March 2014
Parking Status Validation Data

- 21,588 parking events  20 days of varied environmental conditions in Feb - June 2013
- Per space detection accuracy of 97.87%
Video Demonstration

An Automated System For Persistent Real-Time Truck Parking Detection And Information Dissemination

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Parking Space Detection Performance

517,017 parking events across 95,252 time samples
Conflict Detection Examples

Missed vehicles

Maneuvers

Lane encroachment

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Quick Summary

• Persistent per space parking status greater than 95% accurate
• Persistent count accuracy without re-zeroing or recalibration operational maintenance requirement
• In continuous operation at 3 public truck parking facilities between 3 and 4 years (as of May 2017).
Expansion : Wisconsin Integration (2016-2018)

- Implemented and evaluated a regional truck parking notification architecture with TPAS computer vision detection approach
- Deployed at Menomonie WISDOT Public Rest Area
- Parking Notification Integration Using Truck Smart Parking Services (TSPS) TPIMS architecture
- Document guidelines for continued maintenance, site hardware and software configuration
Wisconsin DOT Truck Smart Parking Services (TSPS) 
TPIMS Architecture

TRUCK REST AREA 30 MI. 3 SPACES

Big Spunk Lake Rest Area, Mile 152
Enfield Rest Area, Mile 187
Elm Creek Rest Area, Mile 215
Menomonie Rest Area #61, Mile 43

JSON TSPS Reports

WisDOT implemented Rest area det. tech.

HTTPS Stateless RESTful API

**TSPS/ATMS Server

WisDOT 511 System

WisDOT CMS

3rd Party Data Requests

WisDOT 511 Web

**Management TBD: TOPS Lab or WisDOT

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Site Installation and Design

• Installation costs and effort are site dependent
  – Number of spaces to monitor
  – Geometric layout of parking spaces
  – Existing infrastructure (poles, electricity, comm)
  – Agency/organization equipment requirements
  – Number of sites implemented

• Design and Site Engineering
  – Camera location and system configuration critical
  – Potentially UMN might serve as lead or consultant
Operations and Maintenance

• Site preventative maintenance
  – Clean camera domes & hardware inspection
  – System contains self-monitoring tools to check communications, camera related operations
  – No regular re-zeroing or re-calibrations necessary

• Software updates and maintenance
  – Repository upgrades managed by UMN and private company (in negotiation)
  – Train and build user base community to perform installation and site specific configurations
Future Enhancements and Upgrades

- Use fewer cameras
- Expand to other states (Kansas with 22 rest areas)
- Further relax camera placement constraints
- Key requirement: no regular ‘re-zeroing’ or re-calibration

2-camera 3D reconstruction in development
Kansas Day Scenario

22.44m

41.26m

50.62m

115.52m
Kansas Night Scenario

11.28m  8.42m  20.23m  23.24m
14.96m  19.73m  28.56m
End: Questions?

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Parking Facilities Performance Measures

• Support parking facilities usability and cost/benefit studies

Trucks Database & Data Distrib. Node (.NET & PostgreSQL)

• Capacity trends
• Dwell times
• Per-space usage
  • Weekly
  • Daily
  • Hourly
  • Seasonal
Hourly Space Utilization 08/30/2013 – 09/08/2013

Manually Observed

Detected

Trailer drop