METHODS FOR PROBABILITY ESTIMATION AND DETECTION OF INCIDENTS in

ACTIVE INFORMATION & INCIDENT MANAGEMENT FOR TOTAL ROAD SAFETY

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Motivation

New technologies offer potential for increased road safety

- Improved hardware & software
- Improved integration of dynamic information and traffic management
- Include near-incident and pre-incident conditions
- Preventive vs. responsive strategies
DYNAMIC INFORMATION MANAGEMENT FOR ROAD SAFETY
Goal

- Increase effectiveness of seamless traveler information systems and information-supported traffic management strategies and

- Increase road safety
Objectives

- Seamless transport information for safe travel by all road users with access to internet / cellular device
- Interactive voice response (IVR): Integrated cellular communications, multimedia delivery
- Mobile location based services (MLBS): Personalized information adaptive to user's location, environment, traffic conditions
- Safety information for integrated (interurban-urban) incident and congestion management
Functionalities

- Real-time integration with traffic, public transport, parking data stores
- Dynamic estimation for safety, information, guidance
- Dynamic Location Resolution (GPS etc.)
- User Profiler: Preferences
- Interactions with User Communications
Functionalities

- Dynamic route info (guidance): Alternative & optimum routes based on current vehicle location and safety

- Travel/tourism info (guidance) push to user device, dynamically re-validate towards destination

- Multi-modal, multi-channel: Text/SMS/EMS/MMS/AUDIO HM interfaces, cellular phones, PC/mobile handset/ PDA/ in-vehicle
INCIDENT INTEGRATED MANAGEMENT FOR ROAD SAFETY
Objectives

- Identify Risk Location
- Detect & Verify Incident or near-incident
- Respond & Manage using the complete arsenal of tools available
Functionalities

- Estimation/detection of incident precursor probability – EIPP
- Estimation of incident probability – EIP
- Incident detection – ID
- Estimation/detection of near incident
- Incident verification – IV
- Integrated incident management – IIM (e.g., diversion, ramp metering, dynamic toll, VSLS, VMS, response measures - IR)
Traffic incident

- Incident Id
- Incident Severity
- Incident Source
- Incident Status
- Type of incident
- Time, location of incident
Incident precursor

- Shock wave
- Time headway
- Lane change
- Vehicle trajectory
- Speed variance (intralane, interlane)
- Traffic mix (e.g. % trucks)
- Trajectory in Fundamental Diagram (e.g. hysteresis & capacity reduction)
Performance measures

- Detection rate [%]
- Estimation rate [%]
- False alarm rate [%]
- Time to detect [min]
- Detection accuracy [link based]
Performance measures

Integrated Incident Management [% change]

- MOE 1: Delay in vehicle hours
- MOE 2: Total travel time
- MOE 3: Total travel distance
- MOE 4: Trip time hours
- MOE 5: Speed (on-line)
- MOE 6: Volume (on-line)
- MOE 7: Percent diversion (on-line)
# Modules and sites

<table>
<thead>
<tr>
<th></th>
<th>Incident Probability Estimation</th>
<th>Incident Detection</th>
<th>Incident Verification</th>
<th>Integrated Incident Management Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southampton, Winchester</td>
<td></td>
<td>U06 NN Journey time estimator</td>
<td></td>
<td>RGCNTRAM AIMSUN</td>
</tr>
<tr>
<td>Athens</td>
<td></td>
<td>Call Center</td>
<td></td>
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<tr>
<td>Thessaloniki</td>
<td>U06, DELOS</td>
<td>HLOGIT AIMSUN KIT</td>
<td></td>
<td>AIMSUN, HLOGIT</td>
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<tr>
<td>Barcelona</td>
<td>HLOGIT AIMSUN KIT</td>
<td>Persaud AIMSUN KIT, NN</td>
<td></td>
<td>AIMSUN</td>
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<tr>
<td>Athens</td>
<td>Neural Net</td>
<td>Neural Net, Machine Vision</td>
<td></td>
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<tr>
<td>Munich</td>
<td>U06, DELOS</td>
<td></td>
<td></td>
<td>AIMSUN</td>
</tr>
<tr>
<td>Twin Cities</td>
<td>CE/MTO</td>
<td>DELOS</td>
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</tbody>
</table>
ID Function

- Two sources of detection
  - Sensing equipment
  - Reports from observers, operator

- Multiple algorithms:
  - DELOS, U06, NN, Persaud, IDMV
Sensing: IDMV Operation

3D Raw Video Clips

2D Transformation (Conventional Image)

Video Manager

2D Transformation (Panoramic Image)

Conventional Camera

Traffic Parameters DB

IDMV Module
IDMV Findings

- “3D” Raw Data Machine vision
  - Absolute Error 3.8%

- “2D” Top Down Machine vision
  - Absolute Error 1.7 – 4.9%
  - Absolute Error 1.8 – 4.4%

- Panoramic camera
  - Absolute Error 11%
  - Absolute Error 9.5%
ID – U06 (U.K. algorithm)

Uses average loop occupancy time per vehicle and average time gap between vehicles;

\[ N = \frac{(DL+VL)}{VS} \]

where:

- \( N \) is LOTPV (no. of digital 1’s produced, each representing 250-ms of occupancy)
- \( DL \), effective magnetic length of detector (m)
- \( VL \), effective magnetic length of vehicle (m)
- \( VS \), vehicle speed (m/s)
ID – U06

Detection Rate (%) vs False Alarm Rate (%)

- Thessaloniki
- Southampton
- Threshold
ID Persaud Site Overview (Spain)

- Road Network Geometry
  - 11 Km. Of “Ronda de Dalt”
  - Urban freeway and adjacent urban network with signalized intersections
  - Heavy traffic, high rate of incidents, management: VMS, metering

- Traffic Characteristics
  - 1000 average incidents per year
  - Incident class according to severity: 1 - 5
## Findings

<table>
<thead>
<tr>
<th>Function Tested</th>
<th>MOE</th>
<th>Target</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDPE</td>
<td>Det. Accuracy</td>
<td>300m</td>
<td>500m</td>
</tr>
<tr>
<td></td>
<td>DR</td>
<td>85%</td>
<td>84%</td>
</tr>
<tr>
<td></td>
<td>FAR</td>
<td>0.2%</td>
<td>0.2%</td>
</tr>
<tr>
<td></td>
<td>Time to detect</td>
<td>2 min</td>
<td>2 min</td>
</tr>
</tbody>
</table>
ID Persaud Envelope

![Graph showing the relationship between False Alarm Rate (%) and Detection Rate (%). The graph has a y-axis labeled Detection Rate (%) ranging from 0 to 100 and an x-axis labeled False Alarm Rate (%) ranging from 0 to 0.35. The graph includes points indicating detection rates of 68, 84, 88, and 92 at different false alarm rates.]
IDNN – Incident Severity

Traffic Patterns for Training

<table>
<thead>
<tr>
<th>Sev.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Several vehicles &amp; Casualties</td>
</tr>
<tr>
<td>2</td>
<td>Several vehicles, few casualties</td>
</tr>
<tr>
<td>3</td>
<td>Few Vehicles, no casualties</td>
</tr>
<tr>
<td>4</td>
<td>Minor Incident</td>
</tr>
</tbody>
</table>
## IDNN Performance Findings

<table>
<thead>
<tr>
<th>Period</th>
<th>NN Threshold</th>
<th>DR &gt;85%</th>
<th>FAR &lt;0.2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9</td>
<td>96%</td>
<td>0.1%</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>93%</td>
<td>0.5%</td>
</tr>
<tr>
<td>7</td>
<td>0.9</td>
<td>92%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>
EIP Function

- EIP with HLOGIT statistical approach
  - Real-time traffic conditions, road geometrics, prevailing weather
  - Long data collection period because of seasonal effects
  - Identification of black spots
## Findings

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<th>Target</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIP</td>
<td>ER</td>
<td>80%</td>
<td>83%</td>
</tr>
<tr>
<td></td>
<td>FAR</td>
<td>10%</td>
<td>86%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39%</td>
<td>41%</td>
</tr>
</tbody>
</table>
MTO I-94 Freeway Safety Lab
Data Collection

- Video Recordings
- Individual Vehicle Traffic Measurements
  - Speed, Vehicle Length, Arrival Time at detector
- Loop detector measurements
- Crash Records
### Estimation of crash prone conditions – Findings

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<th>Target</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIPP</td>
<td>DR FAR</td>
<td></td>
<td>68%</td>
</tr>
</tbody>
</table>
IIM Function

- Capable of integrating Urban and Inter-Urban traffic control strategies
- Rule based
- Operator controlled
- Capable of automatic response
Lessons we have learned

- Clear national/regional objective / mandate needed
- Clear jurisdictional responsibilities
- Clear measures of performance, consensus thresholds
- Smooth coordination of dynamic traffic information and traffic management
Lessons – data & information

- Fusion of sensor data
- Subsecond raw data
- Public information: Free access, transparent, fast, always on, location based
- Coordination with new info channels (e.g. vehicle-to-vehicle, driver communities)
- Information security is critical (safety concerns, public trust)