INTEGRATED ASSESSMENT OF SAFETY, ACCESSIBILITY AND RELIABILITY FOR AGING ROADWAY USERS: CASE STUDIES IN FLORIDA

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Meeting the Challenges of Safe Transportation in an Aging Society Symposium
INTEGRATED ASSESSMENT OF SAFETY, ACCESSIBILITY AND RELIABILITY FOR AGING ROADWAY USERS: CASE STUDIES IN FLORIDA

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Meeting the Challenges of Safe Transportation in an Aging Society
Symposium
MOTIVATION

• The population of age group 65 and older is increasing both in U.S. and Florida (a higher rate in Florida).

![Bar chart showing the percentage of the 65+ population in U.S. and Florida.](chart.png)

At 2030, 60-65% increase in number of 65+ persons in Florida

- [http://www.census.gov/population/age/data/2012.html](http://www.census.gov/population/age/data/2012.html) (U.S. Census Bureau)
- [http://edr.state.fl.us/Content/population-demographics/data/Pop_Census_Day.pdf](http://edr.state.fl.us/Content/population-demographics/data/Pop_Census_Day.pdf) (Office of Economic & Demographic Research)
INTRODUCTION

• Surface transportation systems can be effectively utilized to solve transportation safety and accessibility issues facing older adults.

• These issues center on older adults’ need for longer travel time and their heightened health and safety risks.

• Central to meeting these needs are new aging-focused methodologies that will provide agencies with complete, practical, and efficient transportation management and operations procedures.
RESEARCH METHODOLOGY / METHODS

• The first challenge in obtaining such novel methodologies is to extensively evaluate different datasets, including those describing not only older adults’ transportation needs and sociodemographics but also traffic and roadway crash patterns.

• The second challenge is to integrate them, in order to generate comprehensive accessibility, reliability and safety-focused models that jointly considers these databases.

• Our research addresses these challenges by developing a set of Geographical Information Systems (GIS)-based methodologies to assess the roadway networks, focusing on aging populations’ transportation needs and their exposure to transportation-related safety risks.
AGING ROAD USER PRIORITY COUNTIES

2015 Florida’s Aging Road User (65+) Priority Counties

- Top 10 Urban Priority Counties
  - Alachua
  - Bay
  - Broward
  - Duval
  - Escambia
  - Leon
  - Miami-Dade
  - Monroe
  - Orange
  - Seminole

- Top 10 Rural Priority Counties
  - Columbia
  - DeSoto
  - Hamilton
  - Hardee
  - Jackson
  - Levy
  - Madison
  - Putnam
  - Taylor
  - Walton

Percent of Population Aged 65+ by County:
- 9% to 17%
- 18% to 20% (18% statewide average for 2011-2013)
- 21% to 29%
- 30% to 45%

Priority counties were selected using a 3-year (2011-2013) average rate of crashes involving individuals aged 65+ compared to the population of 65+ persons in both urban and rural counties. The chosen counties are the top 10 rural and urban counties.

Sources: Florida Department of Highway Safety and Motor Vehicles
University of Florida Bureau of Economic and Business Research
*As defined by Section 338.6036, Florida Statutes
TRANSPORTATION SAFETY
ANALYSIS: LEON COUNTY, FL

2015 Florida’s Aging Road User (65+) Priority Counties

Top 10 Urban Priority Counties
Alachua
Bay
Broward
Duval
Escambia
Leon
Miami-Dade
Monroe
Orange
Seminole

Top 10 Rural Priority Counties
Columbia
DeSoto
Hamilton
Hardee
Jackson
Levy
Madison
Putnam
Taylor
Walton

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Sources:
- Florida Department of Highway Safety and Motor Vehicles
- University of Florida Bureau of Economic and Business Research

*As defined by Section 398.0086, Florida Statutes
NETWORK KDE ANALYSIS ON LEON COUNTY, FLORIDA
3-D CRASH DENSITY IN LEON COUNTY, FLORIDA
RELIABILITY METRICS

\[ PT\_index = \frac{95^{th}\text{ Percentile TMC travel time}}{\text{Travel time at free flow speed}} \]

\[ \text{Buffer index} = \frac{90^{th}\text{ Percentile TMC travel time} - \text{Median travel time}}{\text{Median travel time}} \]

\[ \text{Probability of congestion} = \frac{\text{Number of observed speeds less than } 10\text{mph of a free flow speed}}{\text{Total number of observed speed samples at each TMC}} \]
### Regression Analysis Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 Coefficient</th>
<th>Model 2 Coefficient</th>
<th>Model 3 Coefficient</th>
<th>Model 4 Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-2.92***</td>
<td>-2.66***</td>
<td>-2.95***</td>
<td>-2.95***</td>
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<td>TMC length</td>
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<td>0.18***</td>
<td>0.19***</td>
<td>0.18***</td>
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<td>log(AADT)</td>
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<td>0.71***</td>
<td>0.70***</td>
<td>0.70***</td>
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<td>log (Median width)</td>
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<td>-0.45***</td>
<td>-0.50***</td>
<td>-0.45***</td>
</tr>
<tr>
<td>log (Surface width)</td>
<td>-0.23***</td>
<td>-0.25***</td>
<td>-0.22*</td>
<td>-0.23***</td>
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<tr>
<td>log (Shoulder width)</td>
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<td>-0.41***</td>
<td>-0.41***</td>
<td>-0.40***</td>
</tr>
<tr>
<td>Posted speed limit (less than 45 = 0 else 1)</td>
<td>-0.24***</td>
<td>-0.3***</td>
<td>-0.28***</td>
<td>-0.30***</td>
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<tr>
<td>log (Probability of congestion)</td>
<td>0.029***</td>
<td>-0.</td>
<td>-0.</td>
<td>-0.</td>
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<tr>
<td>Buffer index</td>
<td>-0.</td>
<td>0.66***</td>
<td>-0.</td>
<td>-0.</td>
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<tr>
<td>Planning time index</td>
<td>-0.</td>
<td>-0.063</td>
<td>-0.</td>
<td>-0.</td>
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</tbody>
</table>

Log(variable name) represents a logarithmic transformation of variables.

*** represents \( p < 0.01 \), ** is \( p < 0.05 \), * is \( p < 0.1 \).
The following algorithms are implemented to predict crash severity in comparison with the traditional regression models:

- A crisp classification algorithm, namely enhanced Particle Swarm Optimization-Multi Layer Perceptron (EPSO-MLP) hybrid algorithm.
- A fuzzy classification; hybrid Adaptive Network-based Fuzzy Inference System (ANFIS) and EPSO algorithm (EPSO-59 FIS).
## COMPARISON RESULTS

Computation time, Estimation Accuracies and the Area Under ROC Curve (AUC) for Proposed Methods; True Positive Rate (TPR, Recall), True Negative Rate (TNR, Specificity), Positive Predictive Value (PPR, Precision), Negative Predictive Value (NPV), F Measure, Classification Accuracy and Area Under Curve.

<table>
<thead>
<tr>
<th>Method</th>
<th>Comp. Time (s)</th>
<th>TPR (Recall)</th>
<th>TNR (Specif.)</th>
<th>PPV (Preci.)</th>
<th>NPV</th>
<th>F Measure</th>
<th>Accuracy</th>
<th>AUC (ROC)</th>
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<td></td>
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<tr>
<td>Miami (All)</td>
<td>46.52</td>
<td>-</td>
<td>0.75</td>
<td>-</td>
<td>0.34</td>
<td>-</td>
<td>0.53</td>
<td>-</td>
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<tr>
<td>Miami (Aging)</td>
<td>11.7</td>
<td>-</td>
<td>0.64</td>
<td>-</td>
<td>0.51</td>
<td>-</td>
<td>0.57</td>
<td>-</td>
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<tr>
<td>JAX (All)</td>
<td>20.65</td>
<td>-</td>
<td>0.37</td>
<td>-</td>
<td>0.76</td>
<td>-</td>
<td>0.59</td>
<td>-</td>
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<tr>
<td>JAX (Aging)</td>
<td>7.39</td>
<td>-</td>
<td>0.92</td>
<td>-</td>
<td>0.23</td>
<td>-</td>
<td>0.56</td>
<td>-</td>
</tr>
<tr>
<td>MLP</td>
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<td></td>
<td></td>
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<td>Miami (All)</td>
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<td>0.77</td>
<td>0.41</td>
<td>0.4</td>
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<td>0.56</td>
<td>0.45</td>
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<td>0.8</td>
<td>0.79</td>
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<td>0.38</td>
<td>0.56</td>
<td>0.56</td>
<td>0.43</td>
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<td>0.78</td>
<td>0.41</td>
<td>0.42</td>
<td>0.56</td>
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<td>0.85</td>
<td>1</td>
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<td>1</td>
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<td>0.71</td>
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<td>EPSO-MLP</td>
<td></td>
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<td></td>
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<td></td>
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<td>Miami (All)</td>
<td>1.94</td>
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<td>0.78</td>
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<td>0.45</td>
<td>0.6</td>
<td>0.59</td>
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<td>Miami (Aging)</td>
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<td>0.68</td>
<td>0.53</td>
<td>0.52</td>
<td>0.6</td>
<td>0.6</td>
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<td>0.43</td>
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<td>1</td>
<td>0.92</td>
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<td>Miami (All)</td>
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<td>0.6</td>
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<td>Miami (Aging)</td>
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<td>JAX (All)</td>
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<td>0.85</td>
<td>0.48</td>
<td>0.48</td>
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<td>0.62</td>
<td>0.38</td>
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<td>JAX (Aging)</td>
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<td>1</td>
<td>0.4</td>
<td>0.15</td>
<td>0</td>
<td>0.56</td>
<td>0.29</td>
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</table>
SPEED RELIABILITY: MIAMI COUNTY, FL

2015 Florida’s Aging Road User (65+) Priority Counties

Top 10 Urban Priority Counties
- Alachua
- Bay
- Broward
- Duval
- Escambia
- Leon
- Miami-Dade
- Monroe
- Orange
- Seminole

Top 10 Rural * Priority Counties
- Columbia
- DeSoto
- Hamilton
- Hardee
- Jackson
- Levy
- Madison
- Putnam
- Taylor
- Walton

Percent of Population Aged 65+ By County
- 9% to 17%
- 18% to 20% (18% statewide average for 2011-2013)
- 21% to 29%
- 30% to 45%

Priority counties were selected using a 3-year (2011-2013) average rate of crashes involving individuals aged 65+ compared to the population of 65+ persons in both urban and rural counties. The chosen counties are the top 10 rural and urban counties.

Sources: Florida Department of Highway Safety and Motor Vehicles
University of Florida Bureau of Economic and Business Research
*As defined by Section 338.0468, Florida Statutes
STUDY AREA

- This research focuses on parallel highways that pass through the Miami-Dade, Broward and Palm Beach counties (These counties include three major metropolitan cities, Miami, Miami Beach and Fort Lauderdale, respectively):
  - I-95, one of the deadliest and busiest interstate highways of the U.S.,
  - Florida’s Turnpike, a busy toll highway, and
  - US-1, a memorial highway with a lower posted speed limit than others

- Heavy traffic is expected on these highways in both directions during extended periods of holidays such as the Thanksgiving week.
VISUALISATION OF SPEED PATTERNS

US-1 Hallandale Beach Thanksgiving week Southbound

- Wednesday
  - 2012
  - 2013

- nth hour of the day
  - Average Harmonic Speed

US-1 Hallandale Beach Thanksgiving week Southbound

- Sunday
  - 2012
  - 2013

- nth hour of the day
  - Average Harmonic Speed

US-1 Hallandale Beach Thanksgiving Week Southbound

- Thursday
  - 2012
  - 2013

- nth hour of the day
  - Average Harmonic Speed
PERFORMANCE OF ALGORITHMS

<table>
<thead>
<tr>
<th>Day</th>
<th>Direction</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Mixing Proportion</th>
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</thead>
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<tr>
<td>Wed.</td>
<td>S</td>
<td>30.21</td>
<td>2.3</td>
<td>56%</td>
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<tr>
<td></td>
<td>N</td>
<td>31.7</td>
<td>3.2</td>
<td>80%</td>
</tr>
<tr>
<td>Sun.</td>
<td>S</td>
<td>30.98</td>
<td>6.2</td>
<td>69%</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>32.53</td>
<td>9.5</td>
<td>91%</td>
</tr>
</tbody>
</table>

(*) X-means algorithm provides only two regimes for the northbound traffic

(*) K-means algorithm provides only two regimes for both north & soundbound traffic

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**Lowest Speed Regime vs Speed Difference - Northbound**

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**Lowest Speed Regime vs Speed Difference - Southbound**
TRANSPORTATION ACCESSIBILITY ANALYSIS: THE WHOLE FLORIDA

2015 Florida’s Aging Road User (65+) Priority Counties

Percent of Population Aged 65+ By County
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Top 10 Rural Priority Counties:
- Columbia
- DeSoto
- Hamilton
- Hardee
- Jackson
- Levy
- Madison
- Putnam
- Taylor
- Walton

Priority counties were selected using a 3-year (2011-2013) average rate of crashes involving individuals aged 65+ compared to the population of 65+ persons in both urban and rural counties. The chosen counties are the top 10 rural and urban counties.

Sources:
- Florida Department of Highway Safety and Motor Vehicles
- University of Florida Bureau of Economic and Business Research
- As defined by Section 388.088, Florida Statutes
COUNTY-BASED AGING ACCESSIBILITY MAPS FOR AIRPORTS: CONGESTED FLOW TRAVEL TIME
EMERGENCY EVACUATION ANALYSIS: BAY COUNTY, FL

2015 Florida’s Aging Road User (65+) Priority Counties

Top 10 Urban Priority Counties
Top 10 Rural Priority Counties
Percent of Population Aged 65+ By County

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Alachua, Bay, Broward, Duval, Escambia, Leon, Miami-Dade, Monroe, Orange, Seminole

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Columbia, DeSoto, Hamilton, Hardee, Jackson, Levy, Madison, Putnam, Taylor, Walton

Priority counties were selected using a 3-year (2011-2013) average rate of crashes involving individuals aged 65+ compared to the population of 65+ persons in both urban and rural counties. The chosen counties are the top 10 rural and urban counties.

Sources:
Florida Department of Highway Safety and Motor Vehicles
University of Florida Bureau of Economic and Business Research
*As defined by Section 288.05059, Florida Statutes
GIS-BASED REPRESENTATION

65+ POPULATION

ORIGINS

DESTINATIONS

65+ POPULATION LIVING INDEPENDENTLY
## COMPARATIVE RESULTS

<table>
<thead>
<tr>
<th>Accessibility</th>
<th>Distance (miles)</th>
<th>Free Flow Travel Time (minutes)</th>
<th>Average Congested Static Travel Times (minutes)</th>
<th>Average Congested Dynamic Travel Time (minutes)</th>
<th>Distance (miles)</th>
<th>Free Flow Travel Time (minutes)</th>
<th>Average Congested Static Travel Times (minutes)</th>
<th>Average Congested Dynamic Travel Time (minutes)</th>
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<tr>
<td>Origin 1</td>
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<td>41.39</td>
<td>48.63</td>
<td>49.73</td>
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<td>11.32</td>
<td>11.76</td>
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<td>3.37</td>
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<td>3.54</td>
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<td>5.88</td>
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<td>Origin 6</td>
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<td>33.08</td>
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<td>40.87</td>
<td>8.63</td>
<td>13.79</td>
<td>14.37</td>
<td>14.43</td>
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</table>

### ARC APPROVED SPECIAL NEEDS SHELTER

<table>
<thead>
<tr>
<th>Accessibility</th>
<th>Distance (miles)</th>
<th>Free Flow Travel Time (minutes)</th>
<th>Average Congested Static Travel Times (minutes)</th>
<th>Best Case Dynamic Travel Time (minutes)</th>
<th>Worst Case Dynamic Travel Time (minutes)</th>
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<td>Origin 1</td>
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<td>Origin 6</td>
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<td>38.90</td>
<td>39.78</td>
<td>43.00</td>
<td>44.50</td>
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PET EVACUATION & OLDER POPULATIONS: MIAMI METROPOLITAN AREA

2015 Florida's Aging Road User (65+) Priority Counties

Top 10 Urban Priority Counties
- Alachua
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- Miami-Dade
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Sources:
- Florida Department of Highway Safety and Motor Vehicles
- University of Florida Bureau of Economic and Business Research
- As defined by Section 398.0655 Florida Statutes
• Although studies have documented the importance of pets in evacuation decision, relatively little is known about either the availability of emergency shelters accepting pets or older adults’ needs for the shelters.

• We focus on the Miami-Dade metropolitan area, the most densely populated area in Florida, 31% of adults aged 65 and older have pets, 40% of whom reported needing help evacuating their pets.
LOGISTIC REGRESSION MODEL RESULTS

• We have conducted logistic regression analysis based on the American Community Survey results based on the U.S. Census.
• Models reveal that needing help with pet evacuation is a significant predictor of public shelter use.
• Specifically, respondents who need help evacuating their pets have 2.5 times greater odds of using a public shelter than those who do not report needing help evacuating their pets.
• We also observe that lacking access to transportation and evacuation funds increases the odds of anticipating the use of a public shelter.
MERGING BEHAVIOR OF OLDER DRIVERS: LEE COUNTY, FL
The 2010 census indicates that in Lee County, Florida, the average age is 45.6 years, higher than the average age of the entire State (40.3 years), thus reflecting a high presence of aging drivers on surroundings highways.
METHODOLOGY

Site selection
- Geometric characteristic
- Traffic characteristics

Data collection

Data reduction

Vehicle trajectory extraction
- Camtasia studio
  - Identification of lag and lead vehicles
  - Gap in time recording
  - Merging sections recording
  - Merging distance in feet

Approach Speed
- Auto scope system
  - Calibration of Auto scope system
  - Placement of speed detectors
  - Define the polling for speed extraction
  - Text files for speeds

Data collection equipment
- Video cameras
- Flexible tripod stand
- Ranging rod
- Speed radar
EXAMPLE RESULTS

**a) Corkscrew**

Young Drivers

- Percentage of gaps vs. gap size (seconds)
- % Rejected Gaps $> t$
- % Accepted Gaps $> t$
- Critical gap = 1.7 sec.

**b) Pine Ridge**

Young Drivers

- Percentage of gaps vs. gap size (seconds)
- % Rejected Gaps $> t$
- % Accepted Gaps $> t$
- Critical gap = 2.7 sec.

**Elderly Drivers**

- Percentage of gaps vs. gap size (seconds)
- % Rejected Gaps $> t$
- % Accepted Gaps $> t$
- Critical gap = 3.1 sec.

**Elderly Drivers**

- Percentage of gaps vs. gap size (seconds)
- % Rejected Gaps $> t$
- % Accepted Gaps $> t$
- Critical gap = 3.8 sec.
CONCLUSIONS

• The application of the proposed methodologies is presented, focusing on various critical issues related to older drivers.
• In particular, we address the following problems: (a) identifying the crash hotspots for older drivers; (b) assessing the accessibility of those hotspots with respect to critical facilities; (c) evaluating the travel time and speed reliability of the roadways in and around those hotspots; and (d) linking this information with aging-related transportation needs and sociodemographic characteristics.
• Several scenarios are studied to show the applicability of the proposed methodologies.
CONCLUSIONS

- Findings of this work can assist in strategic planning efforts for developing appropriate intervention and prevention programs to improve safety and enhance mobility for aging road users.
- The knowledge gained from this research can contribute to the development of more reliable aging-focused safety plans and models.
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