California Highway Patrol
AVs and Enforcement

Assistant Chief Jim Epperson
• American Association of Motor Vehicle Administrators (AAMVA) Autonomous Vehicle Working Group
• Commercial Vehicle Safety Alliance (CVSA) Enforcement and Industry Modernization Committee
• California Transportation Agency Working Group
• California Highway Patrol Working Group
• Oversee CHP Commercial Program
Added Sec. 2, Ch. 570, Stats. 2012. Effective Jan. 01, 2013

*CVC Section 38750 Autonomous Vehicles*

(d) (1) As soon as practicable, but no later than January 1, 2015, the department shall adopt regulations … .

Regulations adopted into Title 13 California Code of Regulations (CCR).
§227.52. Vehicles Excluded from Testing

(a) The following vehicles shall not be approved for testing or deployment as autonomous vehicles on public roads:

(1) Trailers as defined in Vehicle Code section 242 (camp trailer), section 324 (fifth-wheel travel trailer), and section 635 (trailer coach).

(2) Motorcycles as defined in Vehicle Code section 400.

(3) Motor vehicles with interstate operating authority pursuant to Vehicle Code sections 8050 through 8058.

(4) A vehicle with a gross vehicle weight rating of 10,001 or more pounds.

(5) Vehicles that are capable of operation without the presence of an operator inside the vehicle (added in 2015 update).
§227.52. Vehicles Excluded from Testing and Deployment.
(a) The following vehicles shall not be approved for testing or deployment as autonomous vehicles on public roads:

(1) Trailers as defined in Vehicle Code section 242 (camp trailer), section 324 (fifth-wheel travel trailer), and section 635 (trailer coach).

(2) Motorcycles as defined in Vehicle Code section 400.

(3) Motor vehicles with interstate operating authority pursuant to Vehicle Code sections 8050 through 8058.

(4) A vehicle with a gross vehicle weight rating of 10,001 or more pounds.

(5) Vehicles described in Vehicle Code sections 34500 and 31309.
• Currently testing 15 companies, 129 vehicles, and 146 test drivers have been issued permits.

• There have been 21 AV collisions since September 2014. Google has had 18 crashes. The common scenarios are the low-speed autonomous vehicle making a right turn and getting rear-ended by a conventional vehicle.
Guiding Documents

SURFACE VEHICLE
RECOMMENDED PRACTICE

J0619™
SAE INTERNATIONAL

RATIONAL

This Recommended Practice provides a taxonomy describing the full range of levels of driving automation in on-road vehicles and inclusive definitions for advanced levels of driving automation and related terms and definitions. This Recommended Practice does not provide specifications, or otherwise impose requirements on, driving automation. Standardizing levels of driving automation and supporting terms serves several purposes, including:

- Clarity of the role of the (human) driver, if any, during driving automation system engagement.
- Answering questions of scope when it comes to developing laws, policies, regulations, and standards.
- Providing a useful framework for driving automation specifications and technical requirements.
- Providing clarity and stability in communications on the topic of driving automation, as well as a useful short-hand to describe complex systems.

This document has been developed according to the following guiding principles, namely, it should:

- Be descriptive and informative rather than normative.
- Provide functional definitions.
- Be consistent with current industry practice.
- Be consistent with prior art to the extent practicable.
- Be useful across disciplines, including engineering, law, media, public discourse.
- Be clear and coherent and, as such, it should avoid or define ambiguous terms.

The current revision contains updates that reflect lessons learned from various stakeholder discussions, as well as research projects conducted in Europe and the United States by the Adaptation Consortium and by the Crash Avoidance Metrics Partnership (CAMPA) Automated Vehicle Research (AVR) Consortium, respectively.

SAE TECHNICAL STANDARDS BOARD REVIEW

This document is subject to revision. The most current version can be found at www.sae.org.

Copyright © 2016 SAE International. All rights reserved. No part of this document may be reproduced, transmitted, stored, or used in any manner or for any purpose without the written permission of SAE International. SAE International will not be held liable for errors contained herein or for any consequences of its use. This document is subject to revision. The most current version can be found at www.sae.org.

For questions about this document, please contact the SAE Member Services Department at 777 North Kanawha Street, Suite 400, Warrenton, VA 20186-1703 USA. Tel: 703-436-3333 Fax: 703-436-2614 Email: member.services@sae.org

NHTSA
Assessment of Safety Standards for Automotive Electronic Control Systems
Terrain Aided Localization of Autonomous Vehicles

Raj Madhavan
Intelligent Systems Division
National Institute of Standard and Technology
Gaithersburg, MD 20899-8530, U.S.A.
E-mail: raj.madhavan@nist.gov, Fax: (301) 975-2889

Abstract—This paper describes the development of a terrain-aided localization framework for autonomous land vehicles operating at high speeds in unstructured, expansive and harsh environments. The localization framework developed is sufficiently generic to be used in a variety of other autonomous vehicles and can be improved upon and implemented using additional terrain map data. The results demonstrate the robustness of the proposed localization algorithms in producing reliable and accurate position estimates for autonomous vehicles operating in a variety of unstructured environments.

Keywords—Outdoor Localization, Map Building, Random Closest Point, Extended Kalman Filter, Robotic Maps, Safe Space

I. Introduction

The research addressed in this paper is concerned with the theoretical development and practical implementation of reliable and robust localization algorithms for autonomous land vehicles operating at high speeds in unstructured, expansive and harsh environments [1]. Localization is the ability of a vehicle to determine its position and orientation within an operating environment at any given time. The need for localization in an autonomous system is motivated by the requirement of developing autonomous vehicles that can navigate and avoid obstacles in unknown environments. This approach also aims to minimize the segmentation or modification of the environment, such as adding artificial landmarks or other infrastructure, a key driver in the practical implementation of a localization algorithm [2].

II. Map-Based Localization

A map-based localization framework that uses measurements from both artificial and natural landmarks, combined with dead-reckoning sensors, to deliver reliable vehicle position estimates. The proposed localization framework is sufficiently generic to be used in a variety of other autonomous vehicle systems. This proposed framework is designed to be robust to errors in the map data and to be able to handle situations where the vehicle is not near any landmarks.

III. Conclusion

The results demonstrate the robustness of the proposed localization framework in producing reliable and accurate position estimates for autonomous vehicles operating in environments such as mining, agriculture, and construction. This approach also aims to minimize the segmentation or modification of the environment, such as adding artificial landmarks or other infrastructure, a key driver in the practical implementation of a localization algorithm [2].

References


Framework for Improving Critical Infrastructure Cybersecurity

Version 1.0
National Institute of Standards and Technology
February 12, 2014

Autonomy Levels for Unmanned Systems (ALFUS) Framework:
Safety and Application Issues

Hui Min Huang
National Institute of Standards and Technology
Gaithersburg, MD 20899, U.S.A.
hui-min.huang@nist.gov

Figure 1: The Three Aspects for ALFUS

A. Potential Benefits

The ALFUS framework offers many benefits to human life. The ALFUS framework helps characterize the autonomy. This characterization process would, in turn, help the design and evaluation of the UMS.

1. Enhance safety—Human safety is the utmost concern in the modern society. Moreover, those tasks are not suited for humans, particularly those that must be performed in environments that may be dangerous—where heavy machinery may be running, a toxic environment may be occurring, or chemical, biological, radiological, nuclear, and explosive material might exist.

2. Enhance performance—The UMS performance can be optimized to achieve the best possible performance.

3. Enhance efficiency—The UMS can be optimized to achieve the best possible efficiency.

4. Enhance security—The UMS can be optimized to achieve the best possible security.

UMSs are suited for these tasks. The ALFUS framework employs a set of algorithms to facilitate the analysis of the issues and data of metrics to facilitate the analysis of the issues. For example, in a dangerous environment, certain types of UMS may be needed at certain portions of the mission. The difficulty of the task may not exceed certain levels. These are just a few examples for ALFUS application.
Identifying Autonomous Vehicle Technology Impacts on the Trucking Industry

November 2016

Prepared by the American Transportation Research Institute

Autonomous Vehicles Meet Human Drivers: Traffic Safety Issues for States

Prepared for Governors Highway Safety Association

by Dr. James Hedlund, Highway Safety North
Concerns – All Autonomous Vehicles

- People
- Aftermarket
- Maintenance (software)
- Up to Level 3 (people)
- Safety System Failure

- Crash investigation
- Criminal Activities
- Distracted Driving
- Enforcement/Penalties
- First Responder Safety
Unresolved/addressed issues

**External**
- Trip to fueling analysis
- Non-travel issues
  - Freeway emergency (shooting)
  - Evacuations

**Internal**
- Medical emergency
- Driver non-responsive (non-planned need)
- Other mechanical failures
- FMVSS
Concerns – All Autonomous Vehicles

- Law Enforcement and First Responder Training
- Manual Traffic Control
- Response to Emergency Vehicles
- Road Restrictions

- System Misuse and Abuse
- Vehicle Identification
- Rules of the Road
- Fallback (minimal risk condition)
Concerns – Commercial Autonomous Vehicles

- Safety System Failure (Fallback)
- Load Type (HM)
- Load Securement
- Brake Checks (run-away ramps)

- Pre-trip
- Maintenance
- SAE Level 3 / Platooning (Distraction)
- HOS
- Sensors
Object and Event Detection and Response (OEDR)

- Detect and Respond to Speed Limit Changes and Speed Advisories
- Perform High-Speed Merge (e.g., Freeway)
- Perform Low-Speed Merge
- Move Out of the Travel Lane and Park (e.g., to the Shoulder for Minimal Risk)
- Detect and Respond to Encroaching Oncoming Vehicles
- Detect Passing and No Passing Zones and Perform Passing Maneuvers
- Perform Car Following (Including Stop and Go)
- Detect and Respond to Stopped Vehicles
- Detect and Respond to Lane Changes
- Detect and Respond to Static Obstacles in the Path of the Vehicle
- Detect Traffic Signals and Stop/Yield Signs
- Respond to Traffic Signals and Stop/Yield Signs
- Navigate Intersections and Perform Turns
- Navigate Roundabouts
- Navigate a Parking Lot and Locate Spaces
- Detect and Respond to Access Restrictions (One-Way, No Turn, Ramps, etc.)
- Detect and Respond to Work Zones and People Directing Traffic in Unplanned or Planned Events
- Make Appropriate Right-of-Way Decisions
- Follow Local and State Driving Laws
- Follow Police/First Responder Controlling Traffic (Overriding or Acting as Traffic Control Device)
- Follow Construction Zone Workers Controlling Traffic Patterns (Slow/Stop Sign Holders)
- Respond to Citizens Directing Traffic After a Crash
- Detect and Respond to Temporary Traffic Control Devices
- Detect and Respond to Emergency Vehicles
- Yield for Law Enforcement, EMT, Fire, and Other Emergency Vehicles at Intersections, Junctions, and Other Traffic Controlled Situations
- Yield to Pedestrians and Bicyclists at Intersections and Crosswalks
- Provide Safe Distance From Vehicles, Pedestrians, Bicyclists on Side of the Road
- Detect/Respond to Detours and/or Other Temporary Changes in Traffic Patterns
• December 2016 – Nissan North America, Inc. requested an Experimental Equipment Permit for an Autonomous Drive Indicator (ADI).

• The ADI is a light emitting diode light-strip used on autonomous vehicles to signal vehicle intention to surrounding traffic & pedestrians.
Autonomous Drive Indicator

• Testing would be in an urban/suburban environment (no freeways).
• Focus on vehicle motions: Yielding, Stopped, Planning to Go, Creeping, and Going
• CHP issued Experimental Equipment Permit through December 31, 2018.
<table>
<thead>
<tr>
<th>Title</th>
<th>Statute</th>
<th>AV Level</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIVISION 1. WORDS AND PHRASES DEFINED</td>
<td>Sections 100 - 681</td>
<td>Levels 1-2</td>
<td></td>
</tr>
<tr>
<td>210 VC - Automated Enforcement Systems (picture of &quot;driver&quot;)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>305 VC - Definition of &quot;driver&quot; - actual physical control of a vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>312 VC - Definition of &quot;Drug&quot; - effects ability to &quot;drive&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>322 VC - Farm Labor Vehicle definition includes &quot;driver&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>330 VC - &quot;Foreign Vehicle&quot; definition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>336 VC - Reference to &quot;driver&quot; of GPPV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>373 VC - Lessor-lessee - driver of vehicle covered by lease agreement is not considered this if they purchase a leased vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>378 VC - Limousine/Modified Limousine definitions include &quot;driver&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>385.5 VC - &quot;Low speed vehicle&quot; - Autonomous Vehicles may be considered such</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>462 VC - Paratransit vehicle - &quot;utilizing a driver&quot; whether paid or volunteer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>464 VC - &quot;Passenger transportation vehicle&quot; - requires a &quot;driver&quot; to be properly licensed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>521 VC - &quot;retarder&quot; is activated by a &quot;driver&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>545.1 VC - Community college bus driver (not school bus) is required to escort students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>546 VC - SPAB driver requirements i.e., Training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>627 VC - &quot;Engineering and traffic survey&quot; should include highway conditions not readily apparent to the &quot;operator&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>668 VC - &quot;Vanpool Vehicle&quot; includes &quot;driver&quot; in capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>680 VC - &quot;Youth bus&quot; capacity includes &quot;driver&quot; and driver requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIVISION 2. ADMINISTRATION</td>
<td>Sections 1600 - 3083</td>
<td>Levels 1-2</td>
<td></td>
</tr>
<tr>
<td>2802 VC - Inspection of load</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2804 VC - Inspection of equipment, license plates, and registration card</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2806 VC - Inspection of vehicle equipment/driver required to stop and show compliance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2814 VC - Inspections where signs are posted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2814.2 VC - Sobriety checkpoint for &quot;drivers&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2815 VC - Disregard for a crossing guard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2818 VC - Crossing a lane/cone patterns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIVISION 3. REGISTRATION OF VEHICLES AND CERTIFICATES OF TITLE</td>
<td>Sections 4000 - 8808</td>
<td>Levels 1-2</td>
<td></td>
</tr>
<tr>
<td>All sections relating to proof and display of registration and license plates</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Two Approaches to Enforcement

**Bifurcation**
- SAE 1-5
- Rules of the Road
- Driver
- System

**Split by Levels**
- SAE 1-3 All Driver
- SAE 4/5 Vehicle and owner
- OR citing
- Vehicle point system towards suspension/recall

Both equipment dependent.
Crash Investigation

HAV SAE 3-5

**Level 3**
- All Current investigatory elements apply
- Driver/Operator is responsible for vehicle actions
- Search warrant for vehicle information
- Driver/Operator alleged system failure

**Level 4/5**
- Right-of-way violation
- All Current investigatory elements apply
- Owner is responsible for vehicle actions
- Search warrant for vehicle information
- Circumstantial alleged system failure
Jim Epperson
Assistant Chief

Enforcement and Planning Division

California Highway Patrol
601 N. 7th Street
Sacramento, CA 95811
(916) 843-3330
J Epperson@chp.ca.gov