NIST Workshop – Perception Keynote

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Agenda

- Overview
- Vehicle Safety Requirements
- Operational Domain & Perception requirements
- Sensor characterization
- Evolving sensor technology
- ADAS to AV perception
- Evolution timeline threat
- Summary

Overview

Complex System

Autonomous vehicle HW , SW and UX are not difficult under ideal test conditions.

Uncertainty with human drivers on the road, weather , sensor performance and latencies add an order of magnitude to complexity

Public expectations

Evolution of AV is happening on the public stage

Public expectations for AV performance is set very high by not discussing the probability of failure transparently (ASIL D means nothing to public – zero failure shown as goal)

Need for standards

NIST , SAE , ISO , IIHS and other such bodies are needed to establish a common standard for communicating testing and performance (OEMs are too busy developing and competing !)

Vehicle Safety Requirements

Safety Goal

ASIL D :

- 1 dangerous failure in more 10^8 hrs operation

- ~ 0.02 deaths per 100M miles @60 mph

- 2021 USA : 1.5 deaths per 100M miles

- 1.5/0.02 = ~ 75X

Consumer View

- The adoption success of Tesla autopilot despite 736 crashes since 2019 with 17 fatalities – indicates that public is OK with a vehicle that is ~ 3 x to 10X better per Tesla calculations [1] (2022 Q4 : 5M miles per accident vs 0.5M US average ; Vehicle Safety Score calc ~ 3X better ; No deaths/100m unfortunately)

Reset for AV Adoption

- True ASIL rating for deployed AV are likely lower and OK (No ASIL D certifications for vehicle are public)

- Aiming for 75x improvement makes cost of perception higher and delays adoption

- ***Need open discussion to set realistic goals for next 5 & 10 yr timeline - NIST***

Operational Domain & Perception

Roads & Speed

- Paved highway
  - Example: See brick and large pothole > 150m, FoV 45 x 45
- Paved urban
  - Ex: kids / soccer ball , 50m , FoV 360 x 45
- Geofenced...
- Offroad..

Ambient Conditions

- Day / Night
- Sun / Rain / Snow / Fog
- Safe human drivers will reduce speed or pullover if perception is bad
- Sensor perception is acceptable when well characterized

Rating Evaluation

- L4 rating over defined operational domain needs to be certified by a trusted agency
- L4 test will need random edge cases along with testing on public road with safety driver
- A digital model of the vehicle could also be added for simulation testing

NIST to consider:
1. *Sensor requirements and characterization standards*
2. *Testing standards for vehicle L4 rating based on ODD*

Sensor Characterization

Terminology

- Detection (X pts over Y frames)
- Accuracy (over X frames)
- Range
- Resolution
- Region of Interest
- Frame rate

Ambient Conditions

- Sunlight (0 to ~ 100k lux)
- Rain (2.5 to 50 mm/hr)
- Snow (< 1 to > 5 mm/hr)
- Fog (0.25 to > 1 mile visibility)

Target definition

- Size
- Reflectivity
- Color
- Material
- Surrounding targets (Example: 5% Black with retro surrounding)

NIST to consider :
- *Define target, ambient condition, frame rate, detection – then check range, resolution , accuracy over limited frames*
- *Characterize performance with all possible critical targets and ambient conditions in operational domain*

Sensor technology

Mature

- *Lidar*

- Radar

- Visible Camera

- Ultrasonic

- IMU

- GPS

NIST to consider :
1- Role of V2X in AV (Perception at intersections for cross traffic)
2- Potholes , cinder blocks , etc on roads – perception needs

Knocking on Door

- Thermal Camera

- Imaging Radar

- Ground Penetrating Radar

- V2I / V2V

- 2D GPS barcodes in urban canyons

Unmet / Challenges

- Potholes

- Road Surface Condition

- Sensor blockage and cleaning

- Calibration with drift and service – after a fender bender

- Diagnostics for vehicle mechanical parts – motors / wheels / structure / etc.

ADAS to AV – Perception

ADAS (L1 – L2)

- Higher Volumes in near future

- Driver is backup to perception malfunction

- Well defined operational domain and edge cases

- Perception blind spots around vehicle acceptable

AV (L3 – L5)

- Lower volumes in near future

- No backup to take steering wheel control

- ***Operational domain and perception needs cannot be completely defined***

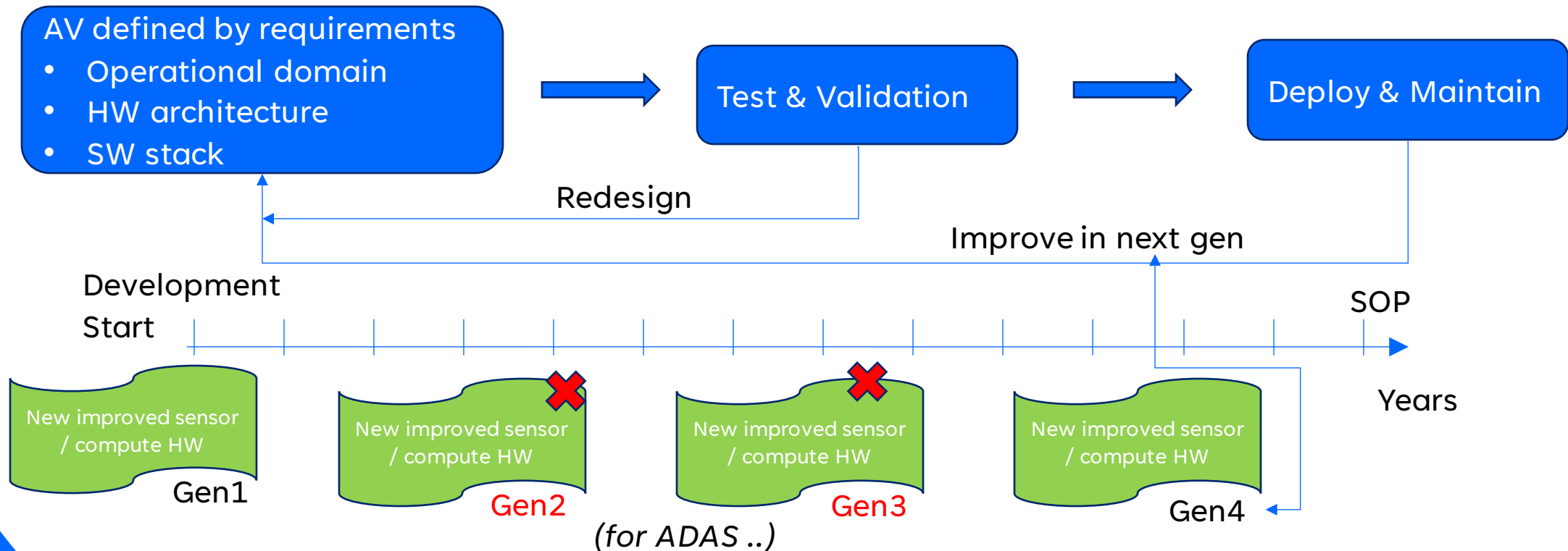- 360 perception around vehicle needed

Comments

- AV adoption needs ADAS volume to reduce costs

- Perception and compute costs of AV are still very high – indicating a long development ramp

- AV stack is orders of magnitude more complex than ADAS

- Perception technology will mature from ADAS for AV adoption

NIST to consider :

- ***Data sharing from AV accidents – what perception / actuation /HW /SW / object on road caused the failure : Like a ML model – add to testing requirements***

Evolution Timeline Threat

AV defined by requirements
- Operational domain
- HW architecture
- SW stack

Test & Validation

Deploy & Maintain

Redesign

Improve in next gen

Development Start

SOP

New improved sensor / compute HW
Gen1

New improved sensor / compute HW
Gen2

New improved sensor / compute HW
Gen3

New improved sensor / compute HW
Gen4

Years

(for ADAS ..)

- Unless perception HW & SW are developed in a modular interface fashion , many new sensor generations will miss adoption

Summary

- AV Safety goal : ASIL D (~ 75X better) Vs Tesla (~ 3X to 10X) Vs Public goal (0 failure)

- Need certification tests for AV with random scenarios based on ODD + simulations

- Characterize sensors over ODD with edge targets and ambient conditions

- 10 yr AV development cycle could strand Newer sensors adoption

- ADAS sensors help AV adoption by bringing costs down – but have different specs

- NIST and other policy bodies have a significant role to play for bringing the safety and convenience benefits of autonomous vehicles to society !

Thank you!

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