AUTONOMOUS VEHICLES & HD MAP CREATION
TEACHING A MACHINE HOW TO DRIVE ITSELF
Ushr Company History

Industry leading & 1st HD map of N.A. Highways (220,000+ miles)
  • Highest Accuracy (3-8cm globally geo-referenced)
  • Highest Quality AQL .5 (99.5%) – AQL .1 (99.9%)

LIDAR Point Cloud Processing Techniques
  • Automated Feature Extraction Techniques
  • Machine Vision and Machine Learning

Scalable data acquisition and frequent updates
  • Proprietary collection / fleet
  • Frequent updates (quarterly, monthly, weekly)

Software Solutions
  • Active Driver’s Map (API eHorizon)
  • Localization/Change Detection Algorithms

Investment/Funding
  • Closed Series A round in November - $10mm
Evolution of Autonomy

Active (control-based) ADAS Solutions
- Active lane keeping, adaptive cruise control, automatic emergency braking, etc.

Partial Autonomy
- GM SuperCruise, Audi Traffic Jam Assist, Tesla Autopilot

Conditional Autonomy (i.e. Piloted Driving) but driver required

Highly Autonomous Vehicle
- Driverless in certain areas

Fully Autonomous Vehicle
- Driverless door-to-door

Driverless Cars: System monitors the road

Automated Driving: Driver monitors the road

SAE Level of Autonomy

Level 1
- Active (control-based) ADAS Solutions

Level 2
- Partial Autonomy

Level 3
- Conditional Autonomy (i.e. Piloted Driving) but driver required

Level 4
- Highly Autonomous Vehicle

Level 5
- Fully Autonomous Vehicle

2010 - 2020 - 2025 - 2030 - 2035 - 2040
Development Cycle of Autonomy

Level 5: Fully Autonomous Vehicle
Driverless door-to-door

Level 4: Highly Autonomous Vehicle
Driverless in certain areas

Level 3: Conditional Autonomy
(i.e. Piloted Driving) but driver required

Level 2: Partial Autonomy
GM SuperCruise, Audi Traffic Jam Assist, Tesla Autopilot

SAE Level of Autonomy
Prototype → Build → Low Volume → Mass Production

Timeline:
2010 → 2015 → 2020 → 2025 → 2030 → 2035 → 2040
Sizing Up the Autonomous Vehicle Market - 2035

By 2035, 18 million partially autonomous vehicles are expected to be sold per year globally.

By 2035, 12 million fully autonomous vehicles are expected to be sold per year globally.

By 2035, autonomous vehicle features are expected to capture 25% of the new car market.

In 2035, 25% of market to be AV sales with 15% partial and 10% full AV systems

Source: BCG Revolution in the Driver's Seat April 2015
Drivers

"Drops me off, finds a parking spot and parks on its own"

43.5%

"Allows me to multi-task/be productive during my ride"

39.6%

"Switches to self-driving mode during traffic"

35.0%

Consumers see a direct benefit in not having to park and being able to do something else during their travel time

Source: World Economic Forum; BCG analysis, consumer survey August 2015
The market for Mobility in 2030 through Audi’s eyes

Total Market

Distribution

Mobility Concept

Unit Sales

Ownership (Exclusive usage)

Sharing (Shared usage)

Vehicle on Demand (VoD)

Mobility on Demand (MoD)

Private

Company Car

Peer2Peer Sharing

Car Rental

Robo Taxi

Robo Shuttle

Source: Evercore Autonomous on Autobahn December 2017
Gartner Hype Cycle

- We are here: 10+ years to adoption for SAE L4/L5
- SAE L2: 2 – 5 years to adoption
- SAE L3: 5 - 10 years to adoption
Driving Evolution

Navigating Roads Safely = More Time Behind The Wheel

Infotainment Systems And Other Electronics “Assist” The Driver

Controlling The Vehicle Is The Driver’s Job

Software And System Glitches Are Not Critical And Can Often Be Resolved Without Affecting Vehicle Operation
Autonomous Driving Evolution

Navigating Roads Automatically & Safely Involves; Sensors, Data Fusion, Decisions, And Vehicle Control

ADAS Systems Must Continually Evolve And Approach New Levels Of Safety, Redundancy And Quality

System Glitches = Customer Dissatisfaction

How Well All Of This Is Done Determines Trust And Technology Adoption
Autonomous Vehicle Value Proposition

Must Drive Better Than Humans
Sensor Fusion Is Essential
Map = Longest Range Sensor
Allows Vehicles To “See” The Road Ahead
  - Pavement Markings
  - Geometric Data
  - Road Objects
  - Derived Data
Applies To All Level Of Autonomous Vehicles

Sensors + Software + Memory (Map) = Knowledge
Autonomous Vehicle Map Challenges

Strategies, vehicle systems, and performance vary
Data needs are different (highways, arterial, local)
Must be ready before customer’s ask for it
Must be updated as frequently as possible
Must include lane by lane level details
Quality levels must meet AQL .1 (99.9%)
Manual map creation methods are not good enough

Acquisition, Processing, And Map Publishing Techniques Must Evolve To Satisfy Autonomous Vehicle Requirements
HD MAPS: Hybrid Set of Attributes

GPS Navigation Map
- Road level accuracy
- GPS accuracy (1-3m)
- Road level routing, Landmarks, Points of Interest
- Fleet of vehicles to capture
- Requires multiple sources to update changes

Civil Engineering Maps
- Survey Grade accuracy road design (<10cm)
  - Road Geometry (Position, slope, etc.)
- Highly detailed 3D Object CAD design
  - Lane level detail (Road bed and roadside)
  - Road Markings and objects (paint, sign, etc.)
- Time consuming collection and feature extraction
  - Traditionally 10x the cost of navigation maps
- Localized projects 1-20 miles long

HD Maps for AD/ADAS
- Lane Level Routing
- Geometric Attributes
  - Trajectory, Slope, Curvature
- 3d Road Objects
  - Signs, Barriers, Etc
- Validation For Safety Cases
- Tools: Manually -> Automated
- Updates -> Real Time
Map Creation - A Delicate Balance

Humans
- Humans are good at higher level logic (Validation)
- Filter false occurrences to direct resources
- Humans present in validation helps streamline results

Machines
- Performs remedial and repetitive tasks
- Promotes true consistency, repeatability and scalability
- Benefits true traceability

The Balance for Optimal Map Creation Comes from The Strengths of Humans and Machines Producing A Mixture of Algorithm Sets (infused with Deep Learning)
Automated Highway Creation

Road Geometry Describes the Drivable Area in Detail
Automated Lane Detection

- HOV lanes
- Bad Paint
- Tunnels
- Botts Dotts

Test Strips
Interstate under construction, the lanes are divided

Machine Learning Algorithms Must Robustly Handle A Wide Range Common Real World Scenarios In Order To Create A Usable Map
Automated Road Object Detection

Object detection varies based on road type.

Highways may be defined with a 100 attributes, where urban local roads may require 500 attributes.

Object classification and detection and localization need to work harmoniously.

Varying the process of object detection and classification can yield improved accuracy and speed.
Automated Road Object Detection

Road Objects Describe How to Traverse the Road
Derived Attributes

Derived attributes play an important part in making autonomous vehicles drive safer.

Potential vehicle collision zones, vehicle virtual paths through intersections, # of lanes, and safe stopping zones, etc.

As autonomous vehicles evolve, data sources will converge to provide more information so the vehicle can make emergency decisions.
Verification and Validation

Machines (learning) cannot learn to do this all by themselves.

Humans will be needed to resolve complex corner cases.

Quality must be designed in versus checked in.

Validation requires map makers to find the optimal balance between humans and machines for the desired output.

Simulation techniques have a place in meeting this challenge.
Safe Autonomous Driving

- Safety = Knowledge
- Knowledge = Sensors, Software, and Memory
- Transient obstacles will increase occurrences of unpredictability
- Autonomous vehicles are a balance of performance, quality and cost
  - OEM’s must carefully manage the adoption of technology change
- Customers will require new relationships with suppliers
  - Unique attributes based on their system performance
  - Crowd Sourced data for only their vehicle fleet
- Vehicle simulators will change the way the AV features are validated

“We are what we repeatedly do. Excellence, then, is not an act, but a habit.” — Aristotle