The Technical Impossibilities of Autonomous Driving

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Prior to his roles at Caruma and Cal, Mark was Director, Computer Vision Products at A9 (Amazon), following their acquisition of The Blindsight Corporation, maker of assistive technologies for low vision and active aging, where he was founding CEO.

Mark has built companies and products in the areas of computer vision, machine learning, financial portfolio optimization, workflow efficiencies, online commerce, development aid data capture and analytics, and film and theatre.

He holds a Ph.D. in Computer Vision from Harvard University.
Autonomous vehicles primer
What it takes to build one
“Technical impossibilities”
Bridge solutions / collateral benefits
Skills needed
Levels of Automation

5 Full
4 High
3 Conditional
2 Partial
1 Driver assistance
Transportation Tech is Exploding
<table>
<thead>
<tr>
<th>Year</th>
<th>Feature Description</th>
</tr>
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<tbody>
<tr>
<td>1912</td>
<td>Cadillac Self-Starter - crankless cranking</td>
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<tr>
<td>1939</td>
<td>Oldsmobile Hydra-Matic Drive AT</td>
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<tr>
<td>1951</td>
<td>Chrysler Hydra-Guide steering</td>
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<tr>
<td>1958</td>
<td>Chrysler cruise control</td>
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<tr>
<td>1970</td>
<td>Chrysler Imperial: sure-break ABS</td>
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<tr>
<td>1997</td>
<td>Toyota radar adaptive cruise</td>
</tr>
<tr>
<td>2003</td>
<td>Mercedes Pre-Safe brakes for moose</td>
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<tr>
<td>2004</td>
<td>Infiniti lane-departure warning</td>
</tr>
<tr>
<td>2005</td>
<td>Volvo blind-spot warning</td>
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<tr>
<td>2006</td>
<td>Lexus parallel-park assist</td>
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<tr>
<td>2007</td>
<td>CMU Tartan wins DARPA GC</td>
</tr>
<tr>
<td>2008</td>
<td>Mercedes Attn Assist - drowsy? warning</td>
</tr>
<tr>
<td>2009</td>
<td>Volvo pedestrian-detection</td>
</tr>
<tr>
<td>2010</td>
<td>Google AV’s on CA roads</td>
</tr>
</tbody>
</table>
1986
Today

**LIDAR UNIT**
Constantly spinning, it uses laser beams to generate a 360-degree image of the car’s surroundings.

**RADAR SENSORS**
Measure the distance from the car to obstacles.

**CAMERAS**
Uses parallax from multiple images to find the distance to various objects. Cameras also detect traffic lights and signs, and help recognize moving objects like pedestrians and bicyclists.

**ADDITIONAL LIDAR UNITS**

**MAIN COMPUTER (LOCATED IN TRUNK)**
Analyzes data from the sensors, and compares its stored maps to assess current conditions.

By Guibert Gates | Source: Google | Note: Car is a Lexus model modified by Google.
Harder than it Looks

George Hotz
"How hard can it be?"
Good driver:

- Safety
- Speed
- Comfort
- Courtesy
More than a Mobile Phone

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Perception & Localization

- **Perception:**
  - Cameras
  - RaDAR
  - LiDAR*
  - ultrasound

- **Localization:**
  - GPS+
  - IMU
  - odometry

- **Supercomputer**
  - new options

Illustration: John MacNeil
Sensors of different capabilities cover 360 degrees, with overlapping fields of view.
Source: Seeking alpha 10/22/2015
AV Supercomputer

- nVidia Drive PX 2 series
- Intel GO platform Atom, Xeon & Arria 10 FPGAs
- Qualcomm Snapdragon 820 Automotive processor

Detection & Tracking

Find, ID & track multiple objects:

- Deep nets trained on hand-labelled datasets
- Pedestrians, cyclists, vehicles, signs, trees, sidewalks, painted lines.
- Output: boxes or pixel-by-pixel labels.

Impossible: complete training

Source: Yu Huang, Baidu
Deep Networks
Deep Networks
Challenges

- Technical
- Legal / regulatory
- Privacy
The Unpredictable
Potential Solutions: Simulation
Partial Solution: HD Maps
Rules of the Road
Official Signal: Context
Connected Car Platform
Tragically, nearly **1.3 million** people around the world are killed in traffic accidents every year.

94% Collisions are caused by human decisions

66% Collisions are caused by distracted driving

56% Fatalities involve aggressive driving

16% Collisions are caused by drowsy driving

*Source: Association For Safe International Road Travel (ASIRT) 2016*
Caruma

State-of-the-art driver assistance with computer vision technology
Caruma Technologies is about to change that with our initial technology offering that combines Big Data analytics, Cloud computing, High-Definition video and advanced mobile connectivity into a powerful vision-based connected car platform.

**Caruma Cloud**
a smart cloud system where video and data are stored and converted into actionable information.

**Caruma Cam**
an intelligent connected device that easily mounts inside any vehicle.

**Caruma App**
Free web and mobile app.
Skills Needed for AV

Deep Learning
Computer Vision
Sensor Fusion
Mapping
Analytics