Self-driving cars

by Hari Chittilla and Dennis Sun
Question

How would you define a self-driving car?
Definition: What is an autonomous car?

- **Autonomous Car**: A driverless vehicle capable of fulfilling the main transportation capabilities of a traditional car.
Classifications of Autonomy according to the NHTSA.

- Level 0: The driver completely controls the vehicle at all times.
- Level 1: Individual vehicle controls are automated, such as electronic stability control or automatic braking.
- Level 2: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping.
- Level 3: The driver can fully cede control of all safety-critical functions in certain conditions and the car provides a "sufficiently comfortable transition time" for the driver to do so.
- Level 4: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time.
Purpose

What kinds of things does a self-driving car need to be able to do?
Purpose

- navigate to a given destination based on passenger-provided instructions
- avoid environmental obstacles
- safely avoid other vehicles
- obey the laws of the road
ANE SOUGHT A BACK, NOT JOHN, HUBBARD PLEASE TO NEED MARRY TO GET A MAN'S MONEY, ACTRESS IS QUOTED.

By Carl Van Vechten, New York. — The second story of the New York Daily News, in the article headed "Woman Sought be Back, Not John, Hubbard Please to Need Marry to Get a Man's Money, Actress is Quoted," is a revealing look into the world of journalism and celebrity culture. The story highlights the complexities of seeking fame and fortune in the entertainment industry, and the challenges that come with it.

PASTOR QUITS CHURCH; LAW IS BETTER PAY

Congregations Unfaithful Preacher Declares in Resignation.

By Fred Van Vechten, New York. — The New York Daily News, in the article headed "Pastor Quits Church; Law is Better Pay — Congregations Unfaithful Preacher Declares in Resignation," explores the dynamics of religious leadership and the impact of financial incentives on pastoral decisions. The article sheds light on the pressures that pastors face when deciding whether to stay in their positions or seek opportunities elsewhere.

LOSES HUSBAND

"Phantom Auto" Will Tour City

A "phantom auto" will soon leave the offices of Milwaukee's Daily News, where it has been touring for the past month, to begin another leg of its journey. The auto, known for its mysterious appearance and eerie sounds, has captivated audiences throughout the city and is expected to continue its travels across the nation.

LAWYER QUITS DIVORCE POST WITH COUNTY

Walter Wallischger was suspended by Wengert at 5:30 A.M.

"Walter Wallischger, suspended as divorce counsel Dec. 14 by Bart Ally, wagon Wengert, as charged by hemorhaphic and effusive counsel toward peers and other than counsel," the article in the Daily News reads. The suspension was a result of the lawyer's documented behavior, which was deemed unprofessional and harmful to the legal profession.

DIVORCING DICK

Salesman in sled for $29,000

"Dick was suspended by a salesman in sled for $29,000," the article in the Daily News states. The salesperson was accused of stealing goods from the store and was subsequently fired. The story highlights the importance of integrity and ethical behavior in the workplace.

CITY SERVICE BOARD WILL NOT WAXE QUIZ

The city service board will not wax a quiz in the benefit of the Wisconsin State Historical Society, in the article headed "City Service Board Will Not Waxe Quiz." The board's decision is a reflection of the priorities and values of the city, and the impact that it has on the community.

09 FOREIGNERS ENROLL AT "U"

"09 foreigners enroll at "U,"" the article in the Daily News states. The enrollment of international students is an essential aspect of the university's mission, and the diversity that they bring to the campus enriches the educational experience for all students.

ANGUSTA GEZELSECHurses' Funeral to Be Today

"Angustas Gezelsehurs' Funeral to Be Today," the article in the Daily News reads. The funeral ceremony will take place at the church, and the community will gather to honor and remember the life of a beloved member of the congregation.
Linrrican Wonder

- Houdina Radio Control, 1925
- Made by Francis P Houdina
- Traveled up Broadway and down Fifth Avenue through the thick of the traffic jam
Futurama

- sponsored by General Motors at the 1939 World's Fair
- radio-controlled electric cars
  - propelled via electromagnetic fields
RCA Labs

● 1953- RCA Labs built a miniature car guided and controlled by wires
● 1958- Full sized system made
  ○ developed in collab. with General Motors
Mercedes Benz

- 1980’s- vision-guided Mercedes-Benz robotic van
  - designed by Ernst Dickmanns and his team at the Bundeswehr University Munich
- achieved a speed of 39 miles per hour (63 km/h) on streets without traffic
History

- Carnegie Mellon’s Navlab and ALV projects in 1984
- Mercedes-Benz and Budeswehr University Munich’s EUREKA Promethius Project in 1987
- Others:
  - Continental Automotive Systems, IAV, Autoliv Inc., Bosch, Nissan, Renault, Toyota, Audi, Volvo, Peugeot, AKKA Technologies, Vislab from University of Parma, Oxford University, Google
  - these companies were more prevalent 2010-2015
DEMO I, II, and III

- US-funded military efforts
- demonstrated the ability of unmanned ground vehicles to navigate miles of difficult off-road terrain
The Grand Challenges (I, II, and III)

- a fundamental problem in science or engineering, with broad applications, whose solution would be enabled by the application of high performance computing resources that could become available in the near future
- Grand Challenges were US policy terms set as goals in the late 1980s for funding high-performance computing and communications research

- DARPA (Defense Advanced Research Projects Agency)
- March 13, 2004 in the Mojave Desert
- No cars finished
- Sandstorm from CMU traveled furthest: 11.78 km (7.32 mi)
## Grand Challenge II (2005)

- 6:40am on October 8, 2005

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Team Name</th>
<th>Team Home</th>
<th>Time Taken (h:m)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stanley</td>
<td>Stanford Racing Team [🔗]</td>
<td>Stanford University, Palo Alto, California</td>
<td>6:54</td>
<td>First place</td>
</tr>
<tr>
<td>Sandstorm</td>
<td>Red Team [🔗]</td>
<td>Carnegie Mellon University, Pittsburgh, Pennsylvania</td>
<td>7:05</td>
<td>Second place</td>
</tr>
<tr>
<td>Highlander</td>
<td>Red Team [🔗]</td>
<td></td>
<td>7:14</td>
<td>Third place</td>
</tr>
<tr>
<td>Kat-5</td>
<td>Team Gray [🔗]</td>
<td>The Gray Insurance Company, Metairie, Louisiana</td>
<td>7:30</td>
<td>Fourth place</td>
</tr>
<tr>
<td>TerraMax</td>
<td>Team TerraMax [🔗]</td>
<td>Oshkosh Truck Corporation, Oshkosh, Wisconsin</td>
<td>12:51</td>
<td>Over 10 hour limit, fifth place</td>
</tr>
</tbody>
</table>
Grand Challenge III (2007) aka Urban Challenge

- November 3, 2007 at the site of the now-closed George Air Force Base
- 96 km (60 mi) urban area course, to be completed in less than 6 hours
- obey all traffic regulations while negotiating with other traffic and obstacles and merging into traffic

<table>
<thead>
<tr>
<th>Team Name</th>
<th>ID#</th>
<th>Vehicle</th>
<th>Type</th>
<th>Team Home</th>
<th>Time Taken (h:m:s)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tartan Racing</td>
<td>19</td>
<td>Boss</td>
<td>2007 Chevy Tahoe</td>
<td>Carnegie Mellon University, Pittsburgh, Pennsylvania</td>
<td>4:10:20</td>
<td>1st Place; averaged approximately 14 mph (22.53 km/h) throughout the course[^6][^7]</td>
</tr>
<tr>
<td>Stanford Racing</td>
<td>03</td>
<td>Junior</td>
<td>2006 Volkswagen Passat Wagon</td>
<td>Stanford University, Palo Alto, California</td>
<td>4:29:28</td>
<td>2nd Place; averaged about 13.7 mph (22.05 km/h) throughout the course[^8]</td>
</tr>
<tr>
<td>MIT</td>
<td>79</td>
<td>Talos</td>
<td>Land Rover LR3</td>
<td>MIT, Cambridge, Massachusetts</td>
<td>Approx. 6 hours</td>
<td>4th Place[^10]</td>
</tr>
<tr>
<td>The Ben Franklin Racing Team</td>
<td>74</td>
<td>Little Ben</td>
<td>2006 Toyota Prius</td>
<td>University of Pennsylvania, Lehigh University, Philadelphia, Pennsylvania</td>
<td>No official time</td>
<td>One of 6 teams to finish course</td>
</tr>
<tr>
<td>Cornell</td>
<td>26</td>
<td>Skynet</td>
<td>2007 Chevy Tahoe</td>
<td>Cornell University, Ithaca, New York</td>
<td>No official time</td>
<td>One of 6 teams to finish course</td>
</tr>
</tbody>
</table>
Google’s Technology

- $150,000 in equipment including a $70,000 LIDAR system
- The range finder mounted on the top is a Velodyne 64-beam laser. This laser allows the vehicle to generate a detailed 3D map of its environment.
- The car uses data collected from these mechanisms to drive itself.
Google’s Technology
How it works: Lidar system

- Laser + radar
- The system detects obstacles and tells the car when to avoid them to navigate safely.
- It uses a 3D point cloud output to provide the necessary data for robot software to determine where potential obstacles exist in the environment and where the car is located relative to those obstacles.
How it works: Velodyne

- Company started experimenting with laser distance in 2005 with the DARPA Grand Challenge
- Since then, they have vastly reduced the size of the sensor and weight while improving its performance.
- It is a premier lidar system
How does communication among driverless cars work?

- vehicles and roadside units as the communicating nodes
  - DSRC devices- 5.9 GHz band with bandwidth of 75 MHz- range of 1000m
Communication among driverless cars cont.

- Smart intersections
  - intersections with no lights that communicate for autonomous cars
  - 2012- University of Texas in Austin
Google’s Track Record

- As of July 2015, Google’s cars have been involved in 14 “minor accidents”.
  - only one had resulted in minor injuries
- They’ve logged 1.7 million miles, and Google claims not a single collision was caused by the self-driving mechanisms
Are we going to see Google on the road soon?

Google plans to make these cars available to the public in 2020.
Other Companies involved (since 1987)

<table>
<thead>
<tr>
<th>Mercedes-Benz</th>
<th>Audi</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Motors</td>
<td>Volvo</td>
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<tr>
<td>Bosch</td>
<td>Peugeot</td>
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<tr>
<td>Nissan</td>
<td>Uber</td>
</tr>
<tr>
<td>Renault</td>
<td>Google</td>
</tr>
<tr>
<td>Toyota</td>
<td>Tesla</td>
</tr>
</tbody>
</table>
Mercedes Benz
Audi
Tesla’s Current Auto Pilot
Potential advantages

- being able to get things done while in traffic or on the road
- increase road capacity
- fewer traffic collisions. Experts estimate 300,000 lives can be saved per decade
- higher speed limits
- reduction in traffic police
- removal of limitations on drivers — age and sobriety won’t be an issue
Potential obstacles

- Liability for damage
- Resistance by individuals to forfeit control of their cars
- Software reliability
- Implementation of legal framework and establishment of government regulations for self-driving cars
- Drivers being inexperienced if situations arose requiring manual driving
- Loss of driving-related jobs
- Loss of privacy
Legislation

In the United States, state vehicle codes generally do not envisage — but do not necessarily prohibit — highly automated vehicles.
Public Opinion

What do you think?

Would you be comfortable with an autonomous vehicle?
Public Opinion

- of 2,006 surveyed consumers, 49% would be comfortable
  - Accenture, 2011
- of 17,400 owners, 37% would be interested purchasing a self driving
  - 2012, J.D. Power and Associates
  - dropped to 20% if the technology costs $3000 or more
- of 1,000 German drivers, 10% undecided, 44% skeptical, 24% hostile
  - 2012, automotive researcher Puls
Discussion: Liability

- Situation: If a traditional automobile gets hit by a driverless car, who is responsible?
- Opinion?
- Take a minute talk with the person next to you and decide what you think.
Discussion: Children

- Situation: Driverless cars may one day be able to pick a child up from school and take him home if the laws permit
- Opinion?
Discussion: Licenses

- If driverless cars are a thing of the future, will driver licenses be a thing of the past?
- Opinion?
- Take a minute talk with the person next to you and decide what you think.
Discussion: Morals

- If there was a choice to swerve into a schoolbus and potentially kill the children onboard but save the driver, or divert the car to kill the driver but save the children, how should the car be programmed?
- A real life application of The Trolley Problem
- Opinions?
- Take a minute talk with the person next to you and decide what you think.
Discussion: Jobs

● Will there still be a demand for auto insurance? What about public transportation and taxi jobs, just to name a few?
● Opinion?
Predictions: Possible Developments

- By 2016, Mercedes plans to introduce "Autobahn Pilot" aka Highway Pilot, the system allows a car to automatically pass someone while driving on a highway.

- By early 2017, the US Department of Transportation hopes to publish a rule mandating vehicle-to-vehicle (V2V) communication.

- By 2018, Elon Musk expects Tesla Motors to have developed mature serial production version of fully self-driving cars, where the driver can fall asleep behind the wheel.
Predictions: Possible Developments

- By 2018, Nissan anticipates to have a feature that can allow the vehicle maneuver its way on multi-lane highways.

- By 2020, Volvo envisages having cars in which passengers would be immune from injuries.

- By 2020, GM, Mercedes-Benz, Audi, Nissan, BMW, Renault, Tesla, Google and Toyota all expect to sell vehicles that can drive themselves at least part of the time.

- By 2020, Google autonomous car project head's goal to have all outstanding problems with the autonomous car be resolved.
Questions?
Thanks

- Dr. Ming Lin