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The Self-Driving Car

The DARPA Urban Challenge of 2007 required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections.

HP Workstation Value Proposition

HP computers are used in nearly every job today. But particularly in designing products or in mission-critical applications, HP Z Workstations, powered by Intel® Xeon® processors, play an important role.

As the market leader in this segment of computing products, HP has dedicated engineering teams that develop the products, integrate them, and manufacture them. HP ships more workstations than any competitor, and in EMEA (Europe, Middle East, and Africa), HP has shipped the most workstations since 2006.

The three main components HP focuses on when developing products are innovation, performance, and reliability. There are many innovations HP has brought to the market first. One example is the tool-less chassis design. Without any tools, the components of the system can be exchanged, upgraded, or serviced. DreamColor technology is a color-matching technology brought to market by HP. Another technology is remote graphics software that can be used to control a computer over a network connection in a very elegant way.

The second topic important to workstations is performance, and of course, HP uses the latest components from partners such as Intel to design those systems. These components are integrated into what HP calls whole system engineering design. HP controls the firmware and everything that goes into the computer to provide the maximum performance to the user, whether in high computing environments or in highly graphics-intensive applications.

The third topic is reliability — mission-critical systems controlling equipment far away. HP tests products under very rigorous conditions. HP mobile workstations are tested according to military standards.

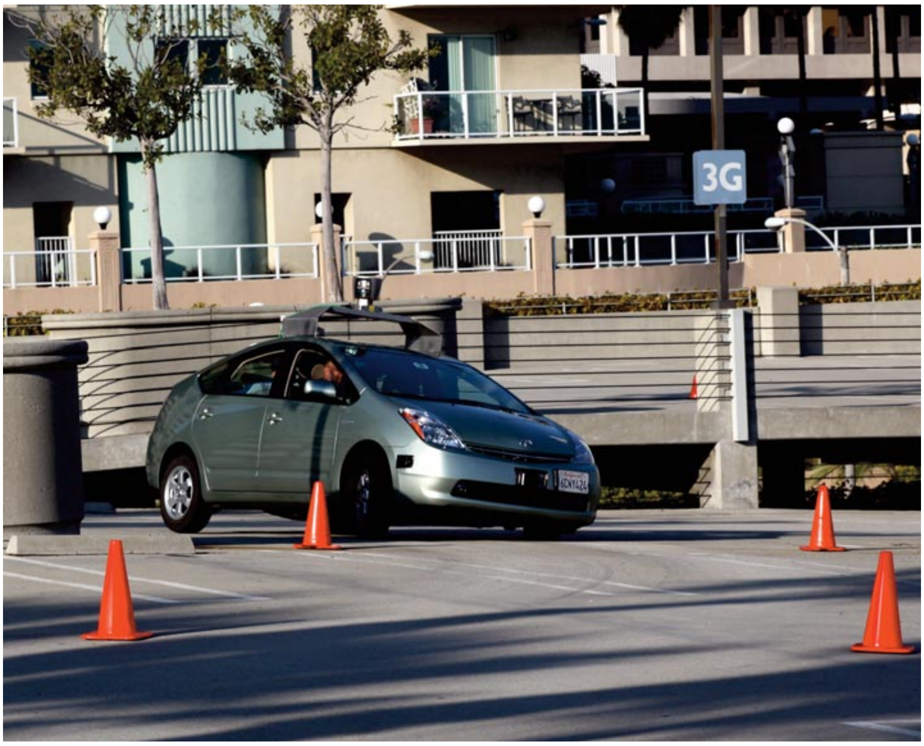
Since the first demonstration of a radio-controlled car in 1925, the automotive industry has been seeking to build a reliable driverless vehicle. The safety of robot-quick reflexes and predictive algorithms, combined with the convenience of effortless travel, is appealing. For those who cannot physically drive, an autonomous car allows a new level of freedom. Of the 5.5 million car crashes per year in the United States, 93 percent of them have a human cause as the primary factor.[1] A self-driving car could reduce such accidents and, as a bonus, use its predictive driving to reduce fuel consumption and traffic congestion.

Automakers are now closer than ever to putting commercial self-driving cars on public roads. States are beginning to legalize automated driving, and components like automatic braking, lane-keeping, self-parking, and adaptive cruise control are found in many modern vehicles.

Yet, the leap from assisted driving to automated driving is substantial. Though it can carry over some aspects from existing vehicles, a self-driving car has to be designed almost from the ground up. To create one that is safe and reliable, automakers must consider a wide array of details like sensor type and placement, a stable onboard computer, incredibly intelligent software, and plenty of system redundancies in case something does fail. Every detail must now assume a computer driver with a human passenger.

Understanding the Problem

Governments, universities, and private companies have been making concerted efforts to develop a self-driving car since the 1970s, but the Grand Challenge presented by the Defense Advanced Research Projects Agency (DARPA) in



A Toyota Prius was modified to operate as a Google driverless car. (Steve Jurvetson)

2004 was the first open competition created to encourage such research. The event and its follow-ups in 2005 and 2007 helped begin much of the modern development of autonomous vehicles. Some manufacturers are diving right into designing fully automated cars, but others are proceeding incrementally, starting with different stages of assisted driving.

The Advanced Driver Assistance Systems (ADAS) in modern cars can provide automakers with useful real-world data, especially as the systems are growing in popularity. In fact, as of 2014, the Euro New Car Assessment Program (Euro NCAP) requires new vehicles to have active safety systems in order to earn the fifth star of their 5-star safety rating system.[2] The United States is expected to follow suit.

Car manufacturers with an interest in creating a self-driving car will be able to gather vast amounts of data from these ADAS to determine which component hardware and software are most effective, and which could be modified and improved. With an eye to the future, they will examine the trade-offs among, for example, radar, lidar, GPS, and optical cameras for different tasks, and how they might be used together.

Manufacturers will also need to model the normal and abnormal behaviors of traffic, drivers, and pedestrians in different driving cultures across the country so they will be able to design sufficiently intelligent software. For vehicles that are likely to have a market overseas, international driving will need to be modeled as well.

Effectively collecting, analyzing, managing, and sharing all that information, both textual and visual, will require not only capable employees, but also specialized software and massive amounts of computing power. With a working understanding of existing automated components, engineers can begin to design the entire self-driving car.

Using the Data: Design and Prototyping

The target product is more than just the sum of its parts. Automobile designers and engineers must make a cohesive product in which every piece is made to fit perfectly with all the rest, physically and functionally.

Besides the usual aspects of automotive engineering such as safety in a crash, performance, and keeping costs manageable, there will be new and important decisions to make, many of which will require several options to be modeled and tested. Will the vehicle use an internal combustion engine or electric? Will consumers prefer a traditional car body or one that reflects the internal innovations? How will the interior reflect the unusual freedom of the person in the driver's seat? Will the car have a steering wheel and pedals so a human driver can take over, or will that option be eliminated? Additionally, the car must meet all federal regulations, be able to communicate with other vehicles and with the infrastructure, and maintain safety redundancies in case something does fail unexpectedly.

Product lifecycle management and collaboration tools become particularly important as the project advances. Engineers and designers will have to work together to ensure no part of the vehicle interferes with the many sensors, or with their ability to communicate with the onboard computer. Assembly feasibility will also be a priority, as it will require extra effort to keep production costs down.

Computer-aided engineering (CAE) and computer-aided design (CAD) will be critical tools through the design and prototyping process. The advent of digital prototyping allows engineers to create and simulate new technology without having to endure the slow and expensive process of physical prototypes over the many iterations expected for such innovation. High-performance computing will allow automakers to support the sophisticated design and analysis software required, and will ensure engineers can efficiently work with the large, intricate CAD models and the simulations used to test them.

Though the use of tangible prototypes has been reduced over time, they are still widely used. Google unveiled their first true prototype of a self-driving car in May 2014 after a few years of working with retrofitted Lexus and Toyota vehicles. Though it has a top speed of just 25 miles per hour, they are using it to test the next step of their own technology.

Physical prototypes are used for aesthetics, too, as few car manufacturers will sign off on a car's body design for production without first seeing a full-scale clay mockup. However, the use of hand-sculpted clay has decreased over the years, and it may be even less necessary by the time self-driving cars are reaching that stage. The process is supplemented with 3D computer-generated images, virtual reality, and computer-aided milling of the clay itself.

Junior, a robotic Volkswagen Passat developed by Stanford University, is capable of navigating urban environments autonomously. It can select its own routes, perceive and interact with traffic, and execute urban driving skills including lane changes, U-turns, and parking. The vehicle successfully finished and won second place in the DARPA Urban Challenge. (Stanford University)

Ensuring Real-World Safety

When automakers test the vehicle prototypes, the safest way to begin will be with the digital prototypes on virtual streets. In the computerized world, it will be possible for automakers to get a good idea of how the car will behave on different types of roads, with various roadblocks, clumsy cyclists, unexpected road work, distracted pedestrians, and even different weather conditions, depending on how the environment is programmed. They will be able to put the vehicle through thousands of possible situations without risking real people or expensive hardware, minimizing the company's liability during initial tests.

Accurately simulating the environment and the vehicle's responses will require mammoth amounts of processing power. If the software is good and the data is reliable, automotive engineers will be able to use it to make adjustments to the vehicle before any physical production begins.

Eventually they will need to put a real car on the road, and every bit of data will have to be carefully gathered and analyzed to ensure the vehicle will always function as expected. Physical prototype tests will likely be re-

Prototype tests of a driverless minibus have been conducted in Spain. The CityMobil 2 electric bus can carry up to 10 passengers and reach a top speed of 40 Km per hour.

quired for legal certification, and to get an even better understanding of the situations that can arise while driving. They will also perform better stress tests of all aspects of the car. For instance, the onboard computer will need to be small, fast, and resilient to the vibrations and stresses of the environment for years. How will it hold up over many rough roads in a harsh climate? Will it fail on a very hot or cold day?

Further adjustments will be made based on these later-stage tests, to both the physical vehicle and to the software that controls it. The software's reliability must be tested and proven in as many likely and unlikely complex situations as possible. It will be necessary to teach the car that, for example, a high-occupancy-vehicle (HOV) lane might only have that restriction during rush hour, or that a school zone speed limit is lower during the hours immediately before and after school. It will also need provisions for recognizing roadwork that changes the number and shape of lanes on a near-daily basis.

Besides all this, the usual crash tests and safety factors will be required. Detailed information from all tests must be shared with engineers and kept up to date so that corrections can be made before the vehicle enters production.

From Concept to Reality

With reliable hardware and software that have been rigorously tested, the final approved autonomous vehicles will be brought to life. Product lifecycle management solutions will be just as important during the production phase. Reducing time to market will be vital as companies race to be the first with a reliable autonomous vehicle, and good PLM solutions will help OEMs collaborate seamlessly with their suppliers.

Developing the car of the future will require immense computing power for data analysis, design, engineering, and simulations. Accurate version control, seamless data sharing, and product lifecycle management become especially critical with such a detail-heavy project. HP workstations, powered by Intel processors, support the needs of automakers in these endeavors. The advanced graphics capabilities, memory, and processors of high-performance workstations allow engineers and designers to create next-generation advancements from their desks.

Learn more at
www.hp.com/go/automotive

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