ENGINEERING INSIDE:

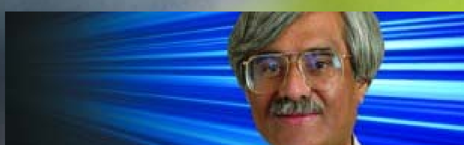
SMART VEHICLES

2015 ISSUE 3

Getting Smart About Getting Around

August 2015

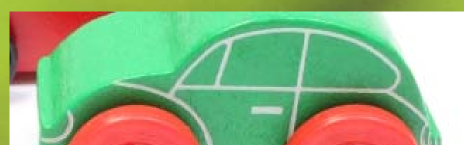
In the future, upgrading your car may involve downloading a software upgrade instead of taking a trip to the dealership. From synching seamlessly with your smartphone to doing the driving itself, smart cars are the future of automobiles and the future starts now.



Meet Mohan Trivedi!

August 2015

Mohan Trivedi is a Distinguished Professor of Electrical and Computer Engineering in the University of California, San Diego's Jacobs School of Engineering. At UC San Diego he serves as the founding director of the Laboratory for Intelligent and Safe Automobiles (LISA) and the Computer Vision and Robotics Research (CVRR) Laboratory.



Design an Energy-Efficient Model Car

August 2015

One of the concerns of engineers working to develop smart car technology is making cars as energy-efficient as possible. In this activity, you'll design a model car two different ways, using everyday office materials. Then you'll test them out to compare their energy efficiency.

Pedal Pusher

See what the Spark crew is up to!

IEEE Spark Challenge

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge! Answer questions correctly to help your team move to the top of the leaderboard.

TIPS AND ADVICE

Build Your Own Smart Car!

Engineering students at the university level have opportunities to try their hand at designing smart cars through competitions.

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IEEE SPOTLIGHT

Smart Car Societies

IEEE has communities and organizations across all disciplines related to the development of smart cars that are dedicated to advancing technology.

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Search for accredited engineering degree programs throughout the world.

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by Robin Hegg

In the future, upgrading your car may involve downloading a software upgrade instead of taking a trip to the dealership. From synching seamlessly with your smartphone to doing the driving itself, smart cars are the future of automobiles and the future starts now.

PARKING SENSORS ON A CAR RAINY DAY

Car manufacturing is beginning to sound more and more like computer and smartphone design, with hardware and software becoming the focus. New cars are already being designed with the hardware manufacturers need for current smart car technology and technology that's expected to become available in the future. For example, in 2014, the Mercedes-Benz C-Class was designed with sensors to judge the distance to cars ahead of it and cameras to read road signs, despite the fact that it wasn't yet ready to make use of them. If cars have the necessary hardware, new technology can become available through software upgrades, much like how a smartphone's capabilities can be expanded with a new update.

Current smart cars are allowing drivers to use their car much like they would their smart phone—to navigate, send text messages, listen to music, and more—all directly from the car itself. In fact, the two biggest smartphone operating systems now have systems designed for cars—Apple CarPlay and Android Auto. These systems are familiar to iPhone and Android phone users and can synch seamlessly with drivers' phones. Other car manufacturers are developing their own software specific to their cars.

Beyond giving cars the ability to more seamlessly give us information and entertainment, smart car technology offers the possibility of allowing cars to communicate with one another, scan their environments, take over certain driving functions, and even drive themselves. All these developments could make driving safer, decrease traffic, and make cars more environmentally friendly and energy efficient.

IN THIS ISSUE:

Jump on board the latest issue of IEEE Spark to explore the exciting world of smart vehicles. Learn how smart vehicles are revolutionizing transportation, meet a professional who is driving the future of smart cars, design an efficient vehicle, and learn how you can enter competitions to design the smart vehicles of tomorrow.

Read this issue!

United States Transportation Secretary Anthony Foxx has stated that connecting all cars in the United States could cut non-alcohol-related accidents by as much as 80 percent. Volvo is working to develop cars that can share dangerous road conditions and cold weather hazards with one another. In February 2015, Britain's Transport Minister Claire Perry announced the launch of four trials of semi-autonomous vehicles. An autonomous shuttle will be tested in the Greenwich of London, and a driverless pod prototype will be tested in central England. Perry called driverless cars, "very good for road safety," saying, "Right now 93 percent of accidents are caused by driver error."

According to an August 2014 report from the Intelligent Transportation Society of America, smart cars with the ability to communicate with each other and roadside equipment could save 420 million barrels of oil over 10 years. Other improvements to traffic infrastructure, such as coordinating traffic to avoid traffic jams, could save an additional 117 million barrels of oil over the same period. Simply by outfitting 1,500 vehicles in its fleet with internet connections and GPS devices. The Smithsonian Institution was able to cut the vehicles' consumption by more than half. The development of more detailed maps and navigation software that could account for the slope of roads could help save fuel by calculating more energy-efficient routes to destinations.

VAN WITH FIVE LIDARS. BY MIKE1024 (PHOTOGRAPHED BY MIKE1024) [PUBLIC DOMAIN], VIA WIKIMEDIA COMMONS

Carmakers and technology companies are working hard to develop autonomous, self-driving cars. These cars offer the possibility of providing transportation to those who may not otherwise be able to drive, like the elderly or the blind. They could also decrease the number of accidents (since it's estimated that 94% of accidents are caused by human error), and decrease traffic jams. In 2012, IEEE predicted that by 2040, up to 75 percent of vehicles on the road will be autonomous. If all cars on the road were autonomous, traffic lights and signs may no longer be needed. In fact, drivers licenses might not be needed either. As of 2015, four states and the District of Columbia in the U.S. have passed legislation allowing driverless cars.

Google has been at the forefront of autonomous car development. They have equipped different types of cars with self-driving equipment. Google's cars use a LIDAR system, which uses a laser beam to generate a three-dimensional map of the car's environment. These cars have now been tested with great results.

Google has also created its own prototype of a driverless car, with no steering wheel or pedals. It presented a fully functioning prototype in December of 2014 and has begun testing them on the road. They plan to make these cars available to the public in 2020.

There is also talk of Google developing a RoboTaxi—a taxi-like vehicle that would be funded by advertising and could function like a new form a public transportation. The transportation company Uber is also reported to be developing driverless cars.

The increased demand on bandwidth that would come with mass vehicle-to-vehicle communication and Wi-Fi use presents a number of issues. Deciding which messages would override others and how bandwidth between can be shared is something that the FCC, car manufacturers, and internet providers are working on.

BY DRIVING_GOOGLE_SELF-DRIVING_CAR.JPG: STEVE JURVETSON DERIVATIVE WORK: MARIORDO [CC BY 2.0 (HTTP://CREATIVECOMMONS.ORG/LICENSES/BY/2.0)], VIA WIKIMEDIA COMMONS

Smart cars also present new security issues. The idea of a smart car being hacked is a frightening one, since hackers could seize control of the car or track its movements. But while cars may be vulnerable to attacks, researchers have found that the hacks needed to access a vehicle’s computers were difficult and expensive, making them less appealing to hackers than smartphones and PCs. A hacker attack on cars would most likely be very targeted. Security companies are working to find vulnerabilities in smart cars so manufacturers can patch these issues before they can be exploited.

Smart car technology is developing quickly and offers up some very exciting pictures of what future transportation might look like. Car manufacturers are already making cars smarter and are working to make cars that will be ready when the technology is.

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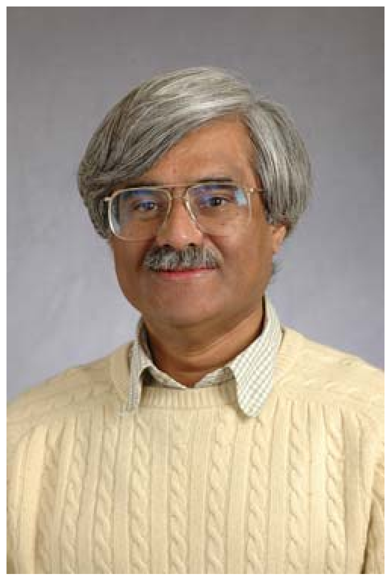

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1. Why did you choose to study the engineering field?

It must be a combination of reasons. I did enjoy learning Physics and Mathematics in school and I used to hear lots of wonderful stories about my grandfather who was a Professor of Engineering.

2. What do you love about engineering?

USEFUL LINKS:

UC San Diego Jacobs School of Engineering
Laboratory for Intelligent and Safe Automobiles (LISA)
Computer Vision and Robotics Research (CVRR) Laboratory

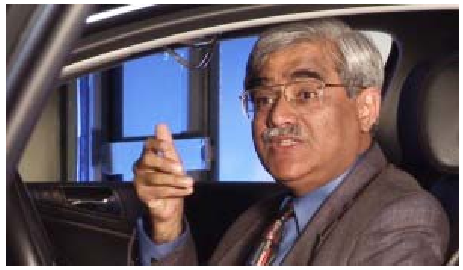
EDUCATIONAL BACKGROUND:

B.E., Engineering; Birla Institute of Technology and Science
Ph.D., Electrical Engineering; Utah State University, Logan

ADVICE TO STUDENTS:

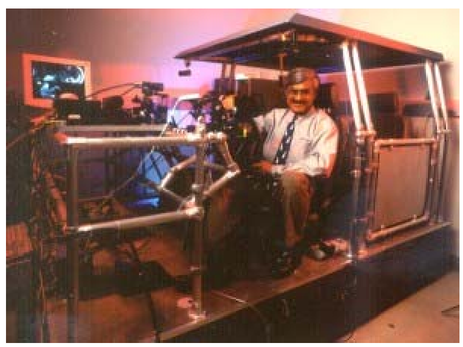
First, I think it's important to remember that advances in intelligent vehicles and transportation will not come from just one field. The smart arena fundamentally requires interdisciplinary research and teamwork, and experience in both areas will be essential for recent graduates who want to take their education and use what they learned in industry or academia.

Almost everything! I think engineers are basically problem solvers. We like to look for problems in the real world and then start on a mission to find solutions by following a systematic process of conceptualization, analysis, design, implementation, and evaluation. I also enjoy doing experimental work to build systems and see them work in the real world. One of the great joys of teaching engineering is the ability to interact on a daily basis with bright students in the lab and in the classroom, and as my students come up with new approaches, there is usually a 'Eureka!' moment that I share with them. Engineering is also, in my experience, a team effort, and that brings great rewards, and our lab has become a training ground for my students to learn skills that will be critical for their futures, whether they go into industry or stay in academia.



3. How did you first get involved with "smart" vehicles? Share a project or inspiration with us please…

Our team was working on intelligent robotics since the mid-1980s, developing robots with multiple sensors to perform various tasks in complex environments. We worked on a range of very interesting projects like autonomous inspection and maintenance tasks in nuclear facilities, development of a cooperative robotic team for autonomous maintenance of high speed train tracks in Japan, and fully autonomous robotic systems for responding to emergencies on highways. Some of these projects had modules, especially those for perception and decision making, which would be important in many smart vehicles. A couple of automakers noticed these efforts and approached us to explore some of the novel features they wanted to implement in their vehicles. We started two projects in 2001. One was related to development of airbags for sensing the size and position of the occupants in the front seat, so that in the case of an accident, the airbag would be properly deployed in order to ensure optimum safety benefits. The second project involved developing a multiple camera-based system that can be used to observe traffic conditions around a vehicle and the state of the driver. These research studies triggered our search for systems to accurately and robustly detect and classify objects on the road as well as conditions inside the vehicles, so that accidents can be prevented.



4. Is there a particular application or industry that you think could benefit the most from smart vehicle advances in the future?
Advances in smart vehicles should make accident-free, congestion free, traveling possible. It also has direct relevance to a whole range of other sectors that will be increasingly enhanced because of advances in the same areas such as computer vision, pattern recognition, and machine learning that will gradually transition from automobiles to other products.

5. You received the 2013 Outstanding Research Award from the IEEE

Intelligent Transportation Systems (ITS) Society – can you tell us a little about the work that inspired this honor?

I was honored to receive the Outstanding Research Award from the ITS Society for my lab's contributions to the newly-emergent intelligent driver assistances systems area, which they dubbed as "pioneering." I have been one of the leading proponents of an "holistic" approach to human-centered active safety systems, combining models for the driver, vehicle, and vehicle surround as well as the various activities associated with the complex task of safe driving. Our research in the Laboratory for Intelligent and Safe Automobiles (LISA) has brought new insights and algorithms for capturing the dynamic surround of the vehicle and the state, intent and activity patterns of drivers. In particular, we have published extensively on what we call the "Looking-in and Looking-out" (LiLo) framework introduced as far back as 2005. LiLo offers a systematic framework to correlate visual context cues from vehicle interior and exterior so that the system can learn and predict driver's behavior and intentions. These ideas are influencing new initiatives and research programs in the field, including those pursued by the Transportation Research Board of the National Academies. Our LiLo approach has already made a major impact on next-generation driver assistance systems under development by major automakers. Immediate examples include panoramic vision systems for parking assistance Lane Keeping Assist (in Germany and Japan), Lane and Merge Intent predication systems for Volkswagen and Audi, and "Holistic Looking-In and Looking-out" algorithms and systems for Toyota.

6. What challenges do we face in the area of smart vehicles? What's the biggest obstacle at the moment?

Never take safety for granted. Think about inadvertent negative consequences of introduction of new technology. There is another subtle challenge posed by the our fascination with the prospect of fully autonomous vehicles. While it makes sense to explore the future of autonomous vehicles, it is also important to consider the role of humans in an autonomous vehicle and come up with a framework where humans and robots work as a team, each aware of the limits, abilities, and intents of the one another, to come up with a synergistic solution.

We can do so much more to improve safety by focusing on human-assisted smart vehicle systems. Widespread use of autonomous vehicles on global roads must be at least a generation away, and it would be unfortunate to divert resources away from important innovations that will save lives and may serve as a transitional stepping-stone to the autonomous vehicles that may one day be possible.

7. Whom do you admire and why?

Leonardo Da Vinci for his unbounded imagination, fantastic creativity and masterful execution of his artistic and engineering skills. On the spiritual and personal side, above all Gandhi-ji for his unflinching belief in human potentiality and the power of nonviolence, empathy for all, transformative leadership, and thinking outside the box.

8. How has the engineering field changed since you've started?

The speed at which our technological world is changing is indeed most impressive. I started engineering by learning a slide rule, doing research using punched cards and batch processing computers, and going to libraries at odd hours in the night to check out reference books, and waiting for weeks to get copies of research papers. How quickly (and most fortunately) such items and practices have been outdated. We are now in the age of instantaneous access to information and a universal knowledge base, and this is certainly not the end of innovations. Powerful machine perception, learning and intelligence algorithms, embedded complex systems, distributed-cloud computing, really *big* datasets, nanotechnology – all are promising explosive growth in our field. It is exciting to think about how our field will look 10, 20 or 50 years from now.

9. What's the most important thing you've learned in the field?

Engineering is not about machines but primarily is about humans and their world. Engineers working as individuals and in teams have found solutions to problems which were considered unsolvable in the past. We have unlimited repository of curiosity, imagination, insights and skills to make a positive and unique impact on the world around us. Understanding the centrality of humans within the context of intelligent vehicles was a lesson that redefined my professional ambitious, and it's a lesson I try to pass on to the students in my lab and in my classes.

10. What advice would you give to recent graduates interested in working in the "smart" arena?

First, I think it's important to remember that advances in intelligent vehicles and transportation will not come from just one field. The smart arena fundamentally requires interdisciplinary research and teamwork, and experience in both areas will be essential for recent graduates who want to take their education and use what they learned in industry or academia. Secondly, the opportunities are endless. There is a lot of excitement in the intelligent systems field. For research-oriented students there are so many challenging problems to solve and for those interested in applications, there are countless exciting domains to work, from interactive games to assistive technology and medical robotics, from smart cars to smart highways and smart cities.

11. If you weren't in the engineering field, what would you be doing?

Maybe I would be an historian or an astronomer! I enjoy learning from the past and am inspired by the infinite possibilities embedded in the universe.

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ENGINEERING INSIDE:

SMART VEHICLES

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Design an Energy-Efficient Model Car

August 2015

by Robin Hegg

One of the concerns of engineers working to develop smart car technology is making cars as energy-efficient as possible. If something is energy efficient, it can use less energy to provide the same service. Efficiency is expressed in percentage and can be calculated using the following formula:

η = energy output (Joules) /energy input (Joules) x 100%

Engineers are working on developing mapping systems that can calculate the most energy-efficient driving routes, developing alternatives to gas engines, and help to avoid traffic congestion, all of which could help to save 420 million barrels of oil over ten years. But before smart car technology comes into play, energy efficiency can begin in a car's basic design. A car's aerodynamics, the resistance of its tires, its size, and its weight are all variables that can affect a car's energy efficiency.

In this activity, you'll design a model car two different ways, using everyday office materials. Then you'll test them out to compare their energy efficiency.

Materials:

Popsicle®/craft sticks

masking tape

Life Savers® or Polo wheel-shaped mint candies

drinking straws

index cards

paper clips

other basic office supplies

gutters or a thin sheet of plywood

stop watch

WHEEL-SHAPED CANDIES

DID YOU KNOW?

BMW recently debuted a car-finder app that helps you locate your car in a parking lot or garage.

A tablet-sized portable transporter dubbed the "car in a bag" was recently developed by a Japanese engineer.

In the near future, smart vehicles are expected to get fuel mileage as high as 190 miles per gallon, or 81 kilometers per liter!

FIND OUT MORE:

You can also visit **TryEngineering.org** to explore other engineering activities and resources. Additional activities and lessons can be found **here**.

Steps:

1. Sketch out a design for your first car.

2. Build your car using the materials you've gathered.

3. Set up a ramp for your car to race down using either a gutter or a thin sheet of plywood. Mark a starting line at the top of the ramp.

4. Race your car and time how long it takes to get down the ramp.

5. Now, choose something to change in your car's design. It can be the car's size, weight, materials, or something else you choose.

6. Race your new car down the ramp and time it.

7. If you'd like, continue to change your car and time its run down the ramp.

8. Using what you've observed, now try to design the fastest, most energy efficient car you can given the materials you have.

9. Test this car on the ramp and see how it compares to your original design.

Questions:

1. How did your different car designs compare with one another? Which of the original car designs was the fastest?

2. Why do you think the faster design was better able to use the energy generated by the slope of the ramp? What design choices do you think contributed to this car's speed?

3. What did you change to make the fastest, most energy-efficient car you could? Which materials did you use and which did you skip? Do you think the materials or the size and shape of the car made more of a difference?

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Build Your Own Smart Car!

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Engineering students at the university level have opportunities to try their hand at designing smart cars through competitions. **The Freescale Cup** is an international challenge where university students build, program, and race a model car. The British Columbia Institute of Technology's IEEE chapter hosts a remote control car race called the **RC Classic**. But there are plenty of opportunities for high school and even middle school students to get designing too.

ANN ARBOR MI – JULY 16: UNIVERSITY OF CALIFORNIA BERKELEY'S SOLAR CAR TEAM MEMBERS RECHARGING THEIR CAR AT THE AMERICAN SOLAR CHALLENGE STOP JULY 16 2012 IN ANN ARBOR MI.

If you've ever dreamed of designing and building your own full-sized car, then the **Solar Car Challenge** might be for you. Engineers are working to make cars smarter—smarter about how they drive, where they drive, and how they get their energy. In the Solar Car Challenge, teams of high school students from schools around the world work to design, engineer, and build their own solar cars, then show them off and race them at the Texas Motor Speedway or on a cross-country drive. Each car has to have a roll cage, safety harness, "crush zones," a horn, a fire extinguisher, communications, and turn signals. Race officials are able to monitor the individual cars using a wireless computer network.

Not ready to make a full-size car? Check out the **Junior Solar Sprint** where 5th through 8th grade students design, build, and race solar powered model cars.

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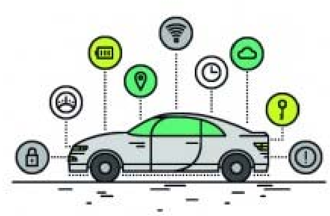
IEEE has communities and organizations across all disciplines related to the development of smart cars that are dedicated to advancing technology and research while fostering collaboration and education.



The **IEEE Transportation Electrification Community** works to coordinate activities throughout the IEEE in the areas of electric and hybrid cars and other vehicles, along with the control technologies and electric grid infrastructure they require.

The **IEEE Intelligent Transportation Systems Society** works to advance aspects of electrical engineering and information technologies as they relate to developing and improving transportation systems of all kinds. The ITSC sponsors a number of conferences, including the **IEEE International Conference on Intelligent Transportation Systems**, the **IEEE Intelligent Vehicles Symposium**, and the **IEEE International Conference on Vehicular Electronics and Safety**.

The **IEEE Control Systems Society** works to advance research, development, and practice in automation and control systems through a wide range of technical interests and applications.

The **IEEE Vehicular Technology Society** works with technology concerning land, air, and sea vehicles, including communications services, electric vehicles, automotive industry equipment and systems, traction power, signals, and communications and control systems for mass transit and railroads. The Vehicular Technology Society sponsors a number of conferences, including its own **Vehicular Technology Conference**, which is held twice a year in the spring and fall. They also sponsor the **International Symposium on Wireless Vehicular Communications**, and the **Vehicle Power and Propulsion Conference**.

IEEE also publishes a number of journals related to smart car technology and research, including IEEE Transactions on Vehicular Technology, IEEE Transactions on Automatic Control, and IEEE Journal on Selected Areas in Communications.

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The award is given every year to recognize outstanding contributions to research in intelligent transportation. Professor Trivedi is an electrical and computer engineering professor at the University of California, San Diego's Jacobs School of Engineering and the director of UC San Diego's Laboratory for Intelligent and Safe Automobiles (LISA). Professor Trivedi was cited for his "contributions to machine vision and learning for intelligent vehicles, and driver assistance and transportation systems." Following the awards presentation, Professor Trivedi delivered a talk in which he questioned whether drivers would really want to hand over all driving responsibility to an autonomous vehicle. He focused on what he calls a driver-centered, holistic approach to intelligent vehicles where driver and car would "share what they perceive and control in a very harmonious manner."

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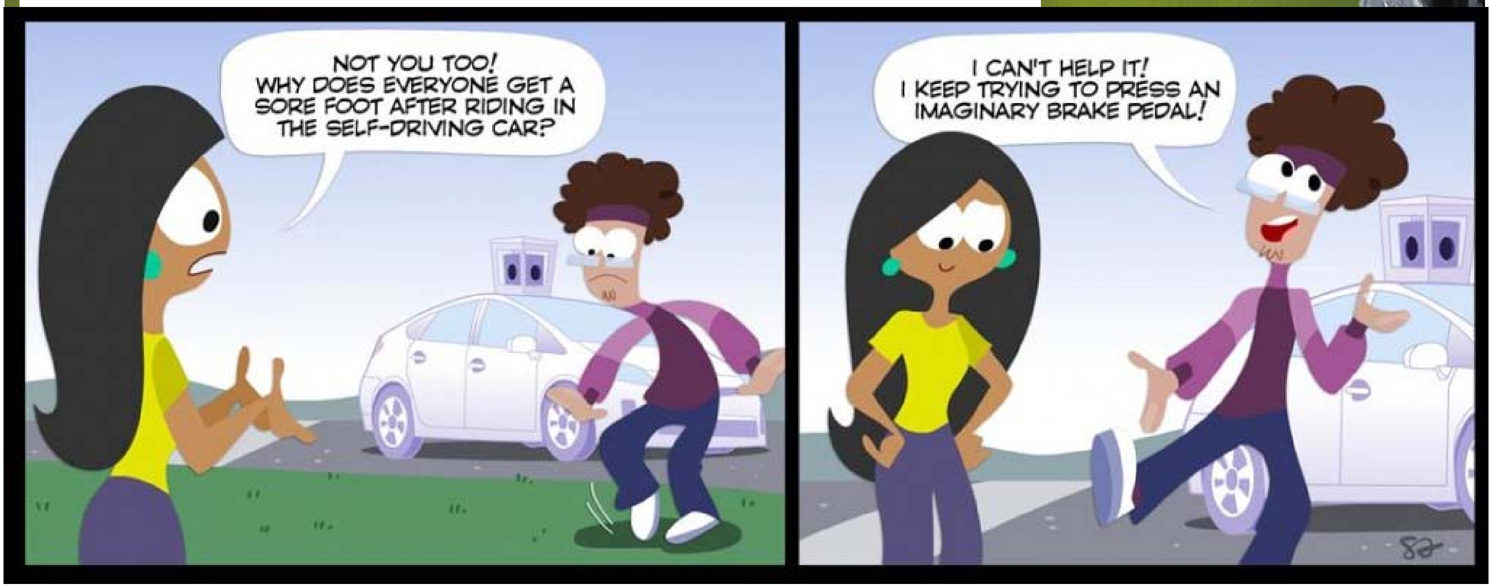

IEEE Spark Challenge: Smart Vehicles

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge!

1) Driverless vehicles are also known as:
    a. autocratic vehicles
    b. autarchic vehicles
    c. independent vehicles
    d. autonomous vehicles

2) Smart vehicles cannot have accidents.
    a. true
    b. false

3) Which is not one of the anticipated benefits of driverless cars?
    a. lower bandwidth usage
    b. lower oil consumption
    c. lower non-alcohol-related accidents
    d. greater mobility for the disabled

4) IEEE predicts that what percentage of vehicles will be driverless by 2040?
    a. 100%
    b. 25%
    c. 50%
    d. 75%

5) Smart cars will employ which of the following technologies?
    a. quasar
    b. sonar
    c. lidar
    d. pulsar

6) In the 1980's which university developed a functioning semi-autonomous vehicle?
    a. Nanyang Technological University
    b. Technion-Israel Institute of Technology
    c. Carnegie Mellon
    d. École Polytechnique Fédérale de Lausanne

7) Which company offered the first car that could parallel park itself?
    a. Lexus
    b. BMW
    c. Toyota
    d. Ford

8) Which of the following is the name of a fictional autonomous vehicle?
    a. Dudu
    b. KITT
    c. Batmobile
    d. Christine
    e. All of the above

9) Google's driverless car has which of the following?
    a. steering wheel
    b. seat belts
    c. gas pedal
    d. brake pedal
    e. none of the above

10) Lidar combines which of the following two technologies?
    a. light and sonar
    b. lasers and radar
    c. Lithium and data
    d. LED and radio

IEEE Spark Challenge: Smart Vehicles
Answer Key

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