The Complicated Role
of Artificial Intelligence in

FUTURE
VEHICLES

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Artificial Intelligence,

which Hollywood latched onto decades ago as the technology motivating mankind-threatening computers, will slowly trickle into vehicles in the coming years, and its prospects for enhancing safety and the driver experience are likely far greater than its mythical past, experts say.

AI core to future of transportation, GM's Reuss says.

"AI is core to the future of transportation, no matter what sort of transportation that is," says Mark Reuss, executive vice president-Global Product Development, Purchasing and Supply Chain at General Motors. "We hope the potential is limitless."

AI is expected to one day be a decision-making superhero, fusing information from a roster of autonomous-vehicle sensors such as Lidar range detectors, precision radar, global positioning systems and a connected transportation ecosystem to deliver us to work or play safely and leisurely.

But AI not only will know when to stop the car, turn left or avoid a stray cat. It also will make interaction with the AV more pleasant by learning our musical tastes, daily routines, favorite restaurants and even when it might be most convenient to grab a cup of coffee along our journey.

With a connection to the Internet of Things, AI will know ahead of our arrival home to open the garage door, turn up the air conditioning and even have the big game from earlier in the day recorded and cued up on the television.

It promises to make driving more enjoyable by vastly improving features such as voice-recognition systems that frustrate car owners today, delivering better fuel economy and fewer tailpipe emissions through optimized performance, and routing us around

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an appointment-breaking traffic jam that may lie ahead.

However, its chief perceived advantage will be saving humans from making the deadly driving mistakes they repeatedly commit today.

"Intelligent vehicles will be as transformative as the Internet and smartphones," says David Atkinson, head of Systems and Technology and Chief Research Scientist for Artificial Intelligence at Continental.

But the road to implementing AI into vehicles is fraught with difficulties. With its black-hat reputation, it is unclear whether consumers will embrace AI in the vehicle. AI expertise is not easy to come by, with professionals numbering in just the thousands worldwide and commanding staggering salaries. Those AI pros are being courted by every industry, too, and in terms of in-house AI expertise the auto industry is on the ground floor.

The auto industry's approach to engineering cars may require a complete reboot from the network of controllers employed today to a central computing system. Those systems must get up to warp speed and there is the emerging question of data storage, because AI likely will need to tap mountains of it to perform safely. AI draws power loads today's vehicle cannot deliver, and the industry must arrive at a solution that does not add too much weight or cost to the vehicle.

Defining AI

Even getting at exactly what AI is can be challenging. Ask 100 AI experts to define the field and odds are they will return 100 different answers. Perhaps the best definition comes from computer scientists Stuart Russell of the University of California and Peter Norvig of Google, two pioneers in

AI systems sense, reason, act, adapt from learned experience, Intel's Krzanich says.

the field. According to Russell and Norvig, AI is any device that perceives its environment and takes actions that maximize its chance of succeeding at some goal.

Also known as cognitive learning and cognitive computing, Intel CEO Brian Krzanich defines AI as computing systems based on the ability of machines to sense, reason, act and adapt based on learned experiences. Put more simply, a machine is intelligent when its patterns cannot be discerned from those of a human.

The auto industry is chiefly concerned with a branch of AI known as machine learning, where algorithms parse data, learn from it and make a correct determination or prediction about something in the transportation ecosystem.

Machine learning almost eliminates the need for humans to identify and tag information, a labor-intensive and sometimes inaccurate process. In the autonomous vehicle, for example, machine learning would perceive a pedestrian, predict that person's next move and then decide how the car should proceed.

But if it were foggy, or weather conditions made it difficult for the

Deep learning uses artificial neurons to analyze pedestrian scenarios.

machine to fully comprehend its environment, perception, prediction and decision-making become blurred.

That's where deep learning, a class of machine learning, steps in. It employs an artificial neural network that mimics human nerve cells to exchange and process information over many layers until it arrives at the most probable outcome.

In the foggy pedestrian scenario, for example, each of the artificial neurons would examine a piece from the scene and assign a weight to its input, or a level of confidence in what it has identified.

The process continues over many neurons and levels of filtering until it reproduces the scene. The network architecture then determines if it is correct and decision-making proceeds – should the car slow down, come to stop or continue along the journey.

Deep learning is especially effective in applications such as the image processing discussed above but also natural-language recognition, where individual speech patterns, accents or dialects are like fog clouding a driver's command.

AI shows big promise, but it also comes with baggage both real and imagined. Since it emerged in the 1950s, AI has witnessed

ups and downs in the technology community, due mostly to the winds of federal funding, and it gained a reputation as a dead-end science.

That opinion still prevails in some circles. Recent advances in computing power, a growing treasure of data and the emergence of deep learning have begun to prove the merit of AI, leaders in the field counter.

Persuading consumers, whose knowledge of the field comes from apocalyptic AI films such as "The Terminator," to let the machines take over may take some doing, though.

Bill Mark, president-Information and Computing Sciences at SRI International, a Menlo Park, CA-based research institute, says drivers will have to reach a level of confidence in AI that they have in their car's brake pedal. He notes the brake pedal stops the car as much as our bare feet; these days, it delegates to a computer to stop the car, but we trust it nonetheless.

"As machines become more complex and intelligent, we

Making Sense of Autonomous Driving Software Buzzwords

Autonomous car software continues to develop at light speed and so do the buzzwords. Here's a quick explainer to help you understand what they mean.

Artificial Intelligence (AI)

The idea that a machine can learn, think and behave like a human.

Autonomous Driving Example: A car programmed to react like a human driver.

SUBSET

Machine Learning

Lots of data is gathered and analyzed to learn how to behave like a human.

Autonomous Driving Example: A car with a high-powered processor that gathers data, allowing it to improve its driving over time.

SUBSET

Neural Networks

Software based on our brain's neural network. Decisions are not absolute, but are assigned a probability.

Chance it will:	Chance it's a:	Chance it's best to:
75% Stay still	**87%** Pedestrian	**82%** Keep speed
24% Move forward	**11%** Mailbox	**12%** Brake hard
1% Back-up	**2%** Other	**1%** Coast

Autonomous Driving Example: A car is able to weigh the probability a pedestrian is about to cross the street or decide what's best to do: maintain speed, stop or coast.

Bonus word: Deep Learning is a method that has helped Neural Networks go from a theory to an effective method to solve complicated problems such as autonomous driving.

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must delegate to them," says Mark, whose group brought the iPhone's Siri technology to market, among other innovations and tech startups. "We need to reach that level of trust."

The talent pool for AI is shallow, too, which hinders the auto industry's ability to recruit enough professionals such as data scientists, machine-learning engineers and computer-vision engineers to meet automated-driving goals that for many companies are right around the corner.

AI is considered by many in the industry as an indispensable technology to reach Level 4 and Level 5 autonomy, but according to Continental's Atkinson fewer than 1,000 AI gurus exist in the world and only 10,000 addi-

tional experts around them have built AI-driven machines. Some experts put the figure higher, but it is generally agreed the shortage is genuine.

This has created a talent war between Silicon Valley and the Midwest, where heavyweights such as GM, Ford, Toyota and Hyundai operate sprawling technical-research campuses. But gaming, healthcare, banking, education, shipping and logistics, retail and advertising also are vying for AI experts.

"That's the core (of talent) for all industries, all sectors, and that is nowhere near enough of a supply, nor are the universities cranking out people quickly enough," Atkinson says. "It is a bigger problem than (AV) testing and verification."

Homegrown Expertise

The shortage likely will lead automotive companies to grow their expertise organically, with fragmented AI intelligence within their engineering houses – a

GM plans 2019 robo-taxi fleet.

vision expert here, a planning and reasoning specialist there and a robotics specialist over there.

The good news is the AI field knows it has a talent deficit. Continuing-education courses are growing, and companies are partnering with online educational institutions for AI training.

AI professionals are costly, as well. A newly minted Ph.D. in the field reportedly can command between $300,000 and $500,000 in salary and company stock options. They are known to renegotiate their compensation packages like professional athletes. Former Google automated-driving expert Anthony Levandowski

piled up $120 million in compensation over a nine-year period before jumping to the ride-hailing service Uber in 2016.

Closer to home in the auto industry, GM paid a reported $1 billion to acquire the San Francisco automated-vehicle startup Cruise Automation in 2016, when the Detroit automaker realized it did not have the specialized smarts in-house to get to a fully self-driving car. Meanwhile, it took a $1 billion investment by Ford in 2017 to get its foot in the door at Pittsburgh-based Argo AI.

"Not many companies are prepared to pay for that," Atkinson says.

GM's Ammann (right), with Cruise Automation's Kyle Vogt, Daniel Kan (left). GM's AI strategy appears to keep expertise in-house through M&A, organic growth.


As such, automakers are taking slightly nuanced approaches to building out their AI expertise.

GM's grab for Cruise Automation, an AI outfit for all intents and purposes, suggests the automaker wants its expertise entirely in-house. Since 2016, the staff of Cruise Automation has grown from 40 to 400. GM also has built out an R&D center in Herzliya, Israel, to enhance its AV development. AI is a key research area of the 100-person group, and Israel is a hotbed for activity around the science.

"All of our focus right now is on moving as fast as we can to get to commercial deployment of this technology in the safest way possible," GM President Dan Ammann recently told Bloomberg. "We believe the best way to do that is having all the capability under one roof."

Ford has taken a slightly different path with Argo AI. The tie-up merges the startup with the Dearborn, MI, automaker's AV development unit. Roboticists and engineers from inside and outside of Ford will develop a
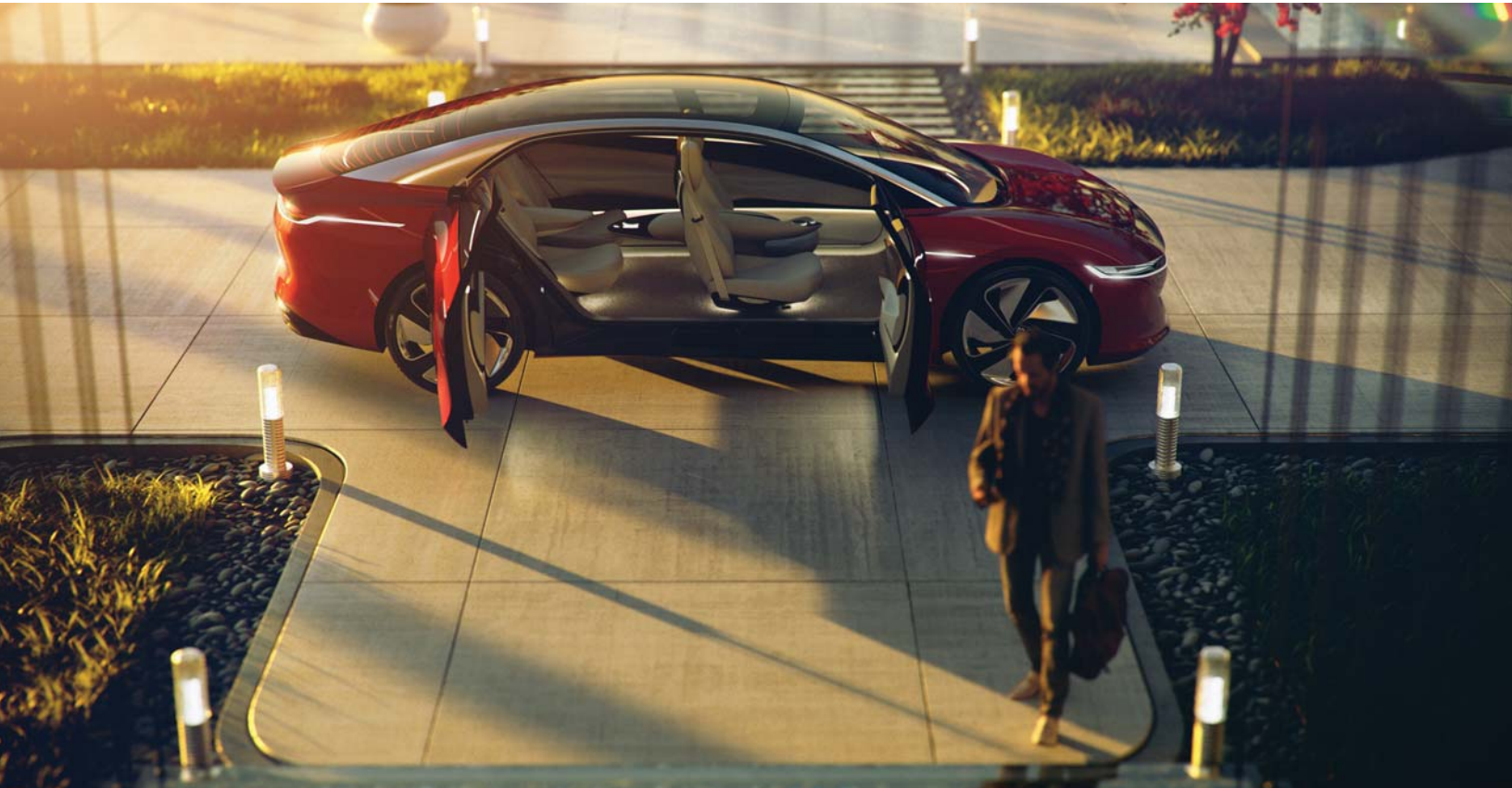
Volkswagen's I.D. Vizzion concept shows potential for AI.

new software platform for full AVs it plans to roll out in 2021. The work between Ford and Argo AI is exclusive to the automaker, although in the future Argo AI could license the solution to other OEMs.

Toyota has taken two paths with AI. The first is rather traditional in that the automaker wants to build regular-production AVs and self-drivers to serve the elderly and disabled in the 2020 timeframe.

But the Japanese automaker also is investing $35 million over a four-year period for AI to revolutionize materials science and identify new advanced-battery materials and fuel-cell catalysts to power future zero-emissions and carbon-neutral vehicles.

In another effort to accelerate the pace of growth in AI more broadly, Silicon Valley-based Toyota AI Ventures looks worldwide for opportunities to invest in AI entrepreneurs and startups.

Continental CEO Elmar Degenhart (left) with NVIDIA founder, CEO Jensen Huang after striking AI partnership.

An early target of the $100 million fund was May Mobility, an AV developer in Ann Arbor, MI.

Fiat Chrysler Automobiles and Germany's BMW are taking a collaborative approach, leveraging the AI expertise of chip maker Intel and its recently acquired vision systems expert Mobileye, which owns proprietary reinforcement learning algorithms to bring human-like driving skills to AVs and to communicate with other cars driven by humans.

Volkswagen also leverages NVIDIA's AI technology in the development of its driverless cars, such

as the I.D. Vizzion and I.D. Buzz concept cars, but also is doing work in-house on its own AI algorithms.

The Volkswagen Group IT Data Lab is a competence center for AI, data analysis and quantum computing. The Munich lab's AI work will fuel advancements in VW manufacturing and logistics, human-robot cooperation, IT security and digital mobility services, the automaker says.

Volvo, meanwhile, has partnered with fellow Swedish company and longtime supplier Autoliv and NVIDIA to develop its AI algorithms.

Suppliers Ramp Up

A long list of traditional suppliers is filling their AI toolbox through work with chip makers with an eye on becoming industry integrators.

Parts makers such as Aptiv, the former electronics unit of Delphi, as well as Magna, Bosch, ZF, Continental and others want to provide automakers with AI-backed AV technology tailored

Industry must rethink engineering model, move to central computing system, says Aptiv's De Vos.

to how OEMs want their cars to perform dynamically.

Just a few years ago, the auto industry would have balked at the idea of a central computing system by arguing that putting all the brain power in place could lead to a catastrophic failure rather than a small, isolated problem like a piston knocking or buggy power window.

In fact, the industry itself sets up its engineering teams according to a car's batches of vehicle systems, an approach that must change ahead of the arrival of AI and Level 4 and Level 5 AVs, says Glen De Vos, senior vice president and chief technology officer at Aptiv.

"We have to start thinking of the car as a digital platform," De Vos says. "And it's a very different way to think about the car."

The future is a smart architecture, or digital platform, where each discrete ECU on the vehicle is centralized into three, or perhaps two and eventually one computing system. The shift must occur, De Vos says, because the computing demands of future vehicles will be

100 times what they are today. If an automaker's architecture cannot meet those demands, customers will go elsewhere.

Moving to a digital platform will not come easily, but automakers will see cost and mass savings through centralization. When Delphi centralized the advanced-driver-assistance-system on the new Audi A3, De Vos notes, there was a 30% savings in mass and cost.

Many experts think it will take more than a decade for the first vehicles with fully digital platforms to arrive, and the shift will be incremental, with parts of the smart architecture laid over traditional ones. But it will be entirely necessary to satisfy the computing loads and speeds AI-driven automated cars will demand.

Chipmaker NVIDIA believes it has a solution. Unveiled last year, NVIDIA Drive PX (also codenamed Pegasus) is an AI computer with the capability to greatly accelerate the rollout of robotic taxis.

Danny Shapiro, senior director-automotive at NVIDIA, says the typical driverless test car running

Future cars Infused with Smart Phone Approach
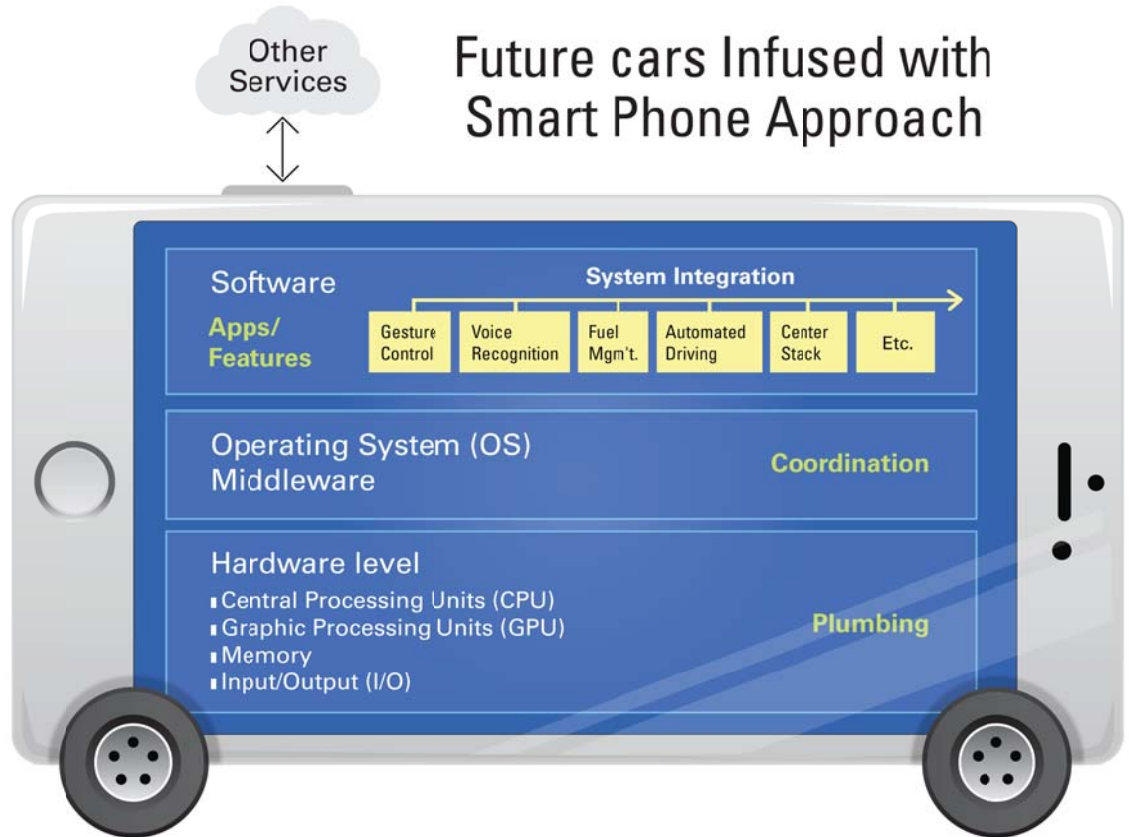
PC-based onboard computing draws between 2,000 and 4,000 watts. Pegasus consumes 500 watts while performing more than 320 trillion operations per second. It is the size of a U.S. license plate and a single unit, or two, would drive a Level 4 or Level 5 AV.

"It's not insignificant (power draw), but it's a savings of many thousands of watts for these vehicles," he says. "So you can imagine if you had an electric car and drove it 10 hours a day. We can save 2,000 watts. That's 20% of the battery.

"What we have done is created a purpose-built device for the car," he adds. "It's automotive grade, it's ASIL-D safety level (-certified) and it is designed to be as energy-efficient as it possibly can."

Data Overload

There also is a question of data storage. AI demands massive amounts of data to make split-second driving decisions,

Data storage emerging issue of AI, Dell EMC's Chhabra says.

but automakers and suppliers also need that data downloaded and stored for further R&D and perhaps as a hedge against yet-undetermined AV liability issues.

For example, Twitter's 270 million users produce about 100 GB of data per day. A single, AI-fueled autonomous test vehicle produces about 30 TB per day, which is 3,000 times the scope of Twitter's daily data.

"The work that is being done by the larger OEMs is unprecedented in this industry in terms of the amount of data it is generating," says Varun Chhabra, senior director-product marketing at Hopkinton, MA-based Dell EMC. "Some of these figures are just staggering."

But it is not just the sheer volume of data confronting the industry. It also is the rapidly expanding task of tagging the data, creating metadata for future use and making it searchable and quickly retrievable.

It is unclear whether data may be disposable, too. When your personal computer or device reaches its data limit, it is easy enough to make more space by deleting files. But in the new frontier of autonomy and ADAS, data may have to be stored perpetually to protect automakers and suppliers from potential legal action if the technology fails in the field.

Automated vehicles also are expected to be on the road longer than today's piloted cars and trucks, which could increase maintenance schedules and put an additional onus on keeping data for an indefinite period.

"It's not a question of being able to store this data in a vault somewhere you will never use. This data is actively used by these companies as they develop these technologies," Chhabra says.

AI technology itself has several bugs to work out before it can be considered safe for deployment. Prediction, or where AI anticipates what drivers, pedestrians and others on or near roadways will do, is a current AV development hang-up, says Gill Pratt, CEO of the Toyota Research Institute.

"Humans are very good at predicting human behavior on the road," he says. "Machines will

Prediction still hurdle for automotive AI, Toyota's Pratt says.

need to be able to predict and anticipate human behavior much better."

AI experts call those difficult prediction situations "corner cases," or those unusual situations where there is insufficient training data. It is an area where humans still have the upper hand on machines.

For example, reams of training data exist for AI to perceive, predict and decide when a deer crosses the roadway or a boy is bouncing a ball near the street. But what about a mattress flying off the top of another car?

Brett Hillhouse, Watson IoT Connected Vehicle Platform & Automotive Solutions Executive at IBM, suggests AI in driverless cars should undergo rigorous certification similar to the scrutiny medical devices carrying the same technology receive from the U.S. Food and Drug Admin.

To this point, the U.S. government has trod lightly on the topic of AI by going only so far as to issue guidelines for AVs.

"There is not the same level of certification you see from the

FDA on medical devices, where essentially you are signing off on all certifications, including an app on your phone that interacts with the medical device," says Hillhouse, whose Watson AI technology is coming to cars. "It must have the same rigor."

However, there is no question the auto industry has set itself on a path to where artificial intelligence will take over not just the menial tasks of driving, but also revolutionize the transportation experience.

The only question remaining may be how fast it will take us there. **WA**

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