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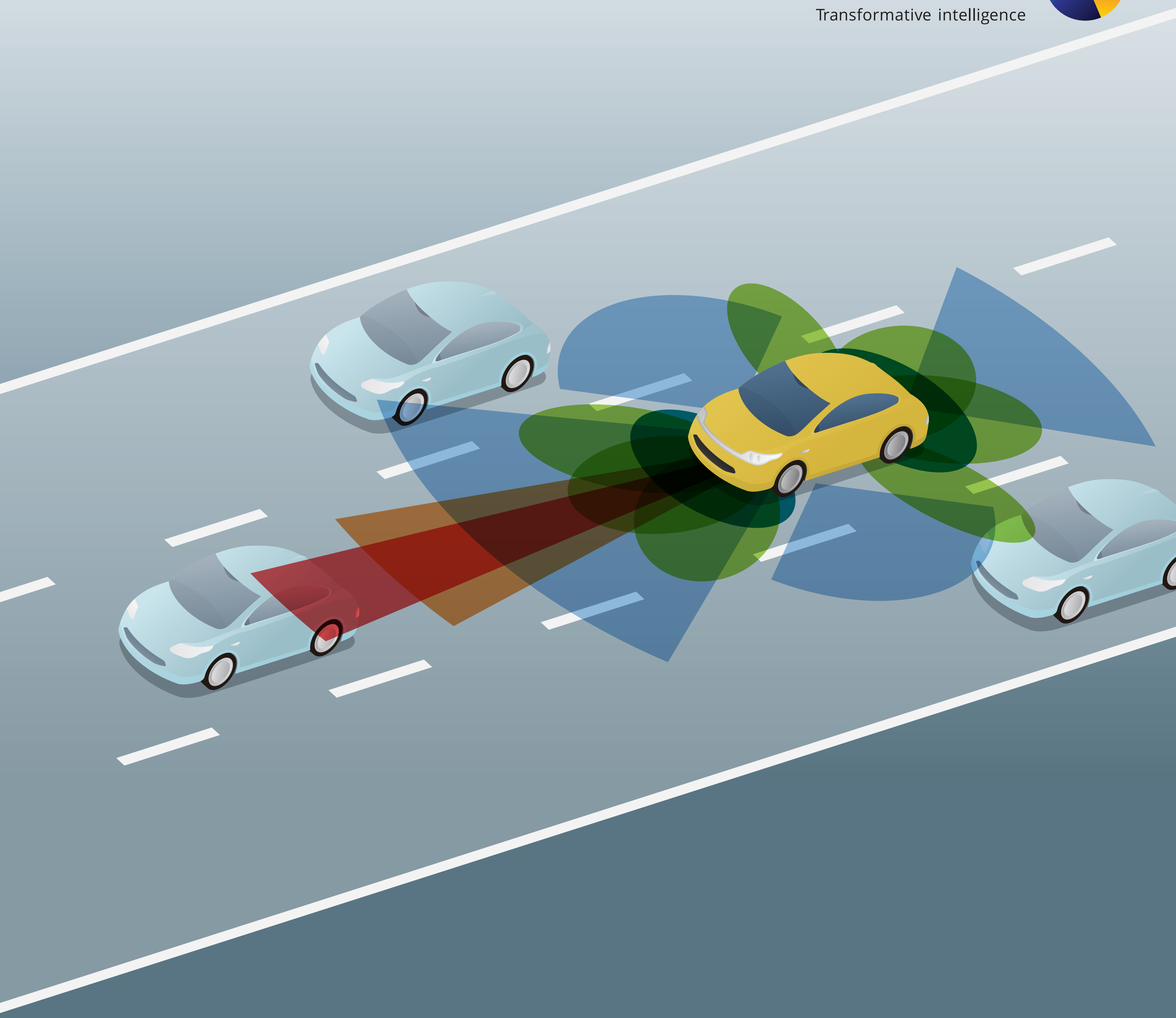

Deep Learning in Autonomous Cars

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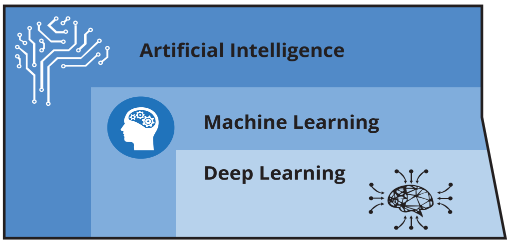
Introduction

The Artificial Intelligence revolution is underway to replicating human intelligence in machines and computers. Many tasks carried out by humans could be replaced by machines in the near future with AI capabilities. To achieve this, artificial intelligence uses algorithms to parse data, learn from it, and then make a determination or prediction called Machine Learning. The machine is "trained", using large amounts of data and algorithms that give it the ability to learn how to perform a task. Artificial Neural Networks, better known as Deep Learning, was developed to implement even better machine learning.

Deep Learning

Neural Networks are inspired by our understanding of the biology of our brains – all those interconnections between the neurons. But, unlike the biological brain, where any neuron can connect to any other neuron within a certain physical distance, these artificial neural networks have discrete layers, connections, and directions of data propagation.



A bunch of data is fed into all the layers, from the first to the last, until an output is produced. Each neuron assigns a weightage to its input about how correct or incorrect the data is, relative to the task being performed. The final output is then determined by the total of these weightages.

Deep Learning in Autonomous Cars

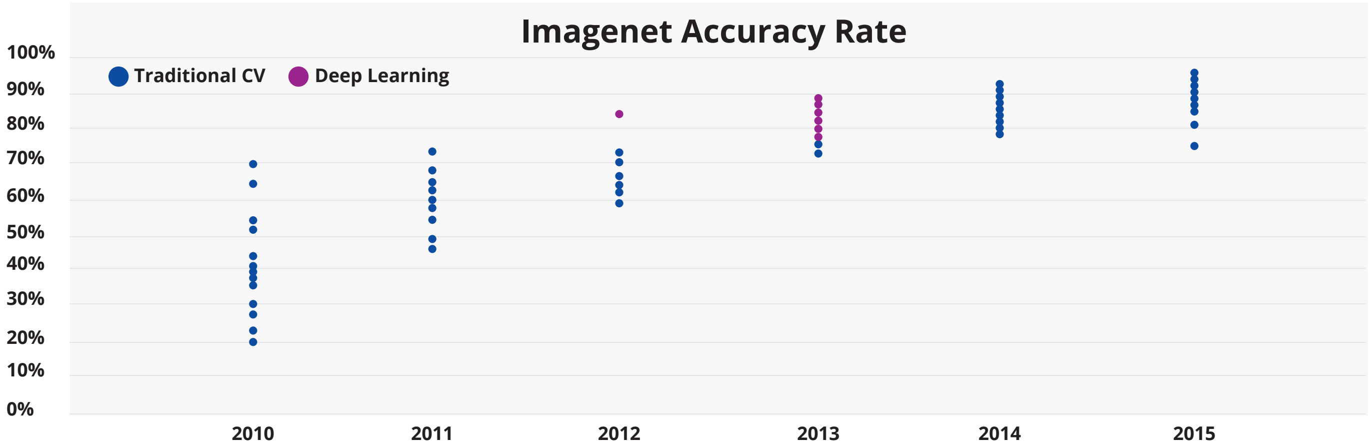
Technology has seen plenty of advancements over the decades, with cars nowadays being equipped with several sensors such as LIDAR, cameras, radars and more. With different technologies being adopted in the car, a supercomputing chip with Deep Learning technology is what helps to drive the car.

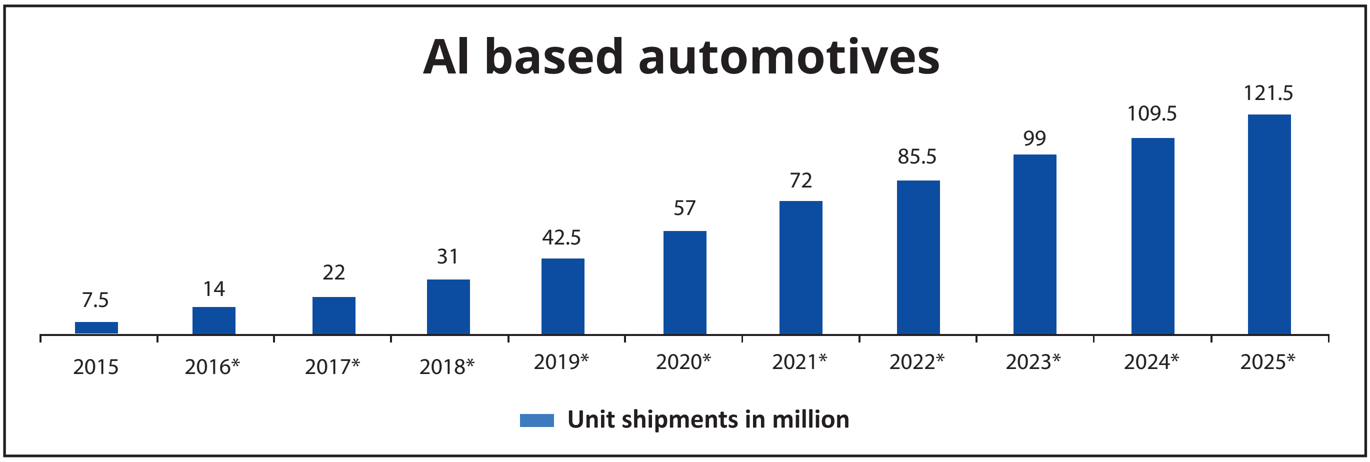
Computer vision was expected to play a larger role within autonomous driving. However, due to its history of relatively low precision, it is typically used in conjunction with either other sensors or other road models. On the other hand, Deep Learning, or neural networks, represents an alternative approach to classic computer vision, as it shows considerable promise as a solution to overcome the latter's shortcomings. Recent progress in the field has advanced the feasibility of deep learning applications to solve complex, real-world problems and the industry has responded by increasing the uptake of such technology. Deep learning is data centric, requiring heavy computation but minimal hand-engineering. In the last few years, an increase in the available storage and compute capabilities has enabled deep learning to achieve success in supervised perception tasks, such as image detection. A neural network, after training for weeks, or even days, on a large data set, can be capable of inference in real-time with a model size that is no larger than a few hundred MB. State-of-the-art neural networks for computer vision require very large training sets coupled with extensive networks, capable of modeling such immense volumes of data.

Growth of Deep Learning

Deep Learning is making great strides in recognizing objects (up to 95% accuracy) compared to the traditional computer vision (CV) algorithms. It is being applied worldwide in the automotive market in areas such as computer vision, natural language processing, sensor fusion, object recognition and autonomous driving projects. Autonomous driving startups, Internet companies and established OEMs are exploring the use of graphical processing units (GPUs) for neural networks to ultimately make cars drive autonomously.

With the adoption of autonomous cars and electric vehicles gaining momentum in developed markets, companies are now mainly focusing on getting ahead of the competition by investing heavily in such areas.





Carol Reiley
President and Co-founder of Drive.ai.

"Deep learning is the closest algorithm to how the human brain learns; it's not rule-based. It's much like how a 16-year-old, or a young driver learns. Instead of hard-coding rules, you're given a lot of different examples —what is right, wrong, safe, what is a car, what is not a car. It starts to generate its own set of rules on how to navigate in the road."

How Deep Learning is used?

Lane detection: Deep Learning helps in lane detection by predicting the lane boundary across the road. It helps the car to stay within specific lanes by using the paint on the roads, there by predicting the lanes. Different lanes are represented by different colors and the lane is predicted in 3D using inverse camera perspective mapping.

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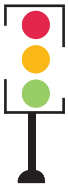
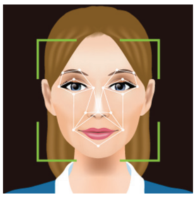
Pedestrian detection: Cameras are used to detect objects and pedestrians. Objects are labelled with the help of machine learning and are processed by the central processor which orders specific actions, such as avoidance of pedestrians, barriers.

Road sign recognition: Deep learning helps in recognizing road signs, parking signs. These signs are analyzed by algorithms and appropriate action is taken.

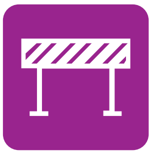


Traffic light detection: In order to comply with traffic rules and traffic lights, Deep Learning helps the autonomous cars detect light at traffic signals and take appropriate action.



Face detection/recognition: Facial detection/recognition can be a useful feature for owner recognition, so that the car can identify its owner. As a security measure, it can help prevent the car from being stolen or from falling into the wrong hands. Face detection of the public/pedestrians outside the cars might also help the car take preventive action.

Car detection: Sensors are fitted around the car to capture images and detect vehicles and objects, with help of Deep Learning. This in turn, helps in identifying and processing data to maintain the car's position with regard to other moving/stationary vehicles.



Obstacle detection: Obstacles can be detected using other means such as ultrasound, but the car needs to also use its camera systems to determine the presence of obstacles.

Environment recognition: Several sensors such as LIDAR, Radar, are used to scan objects and identify the environment outside the car, using Deep Learning. It helps the car to determine where it is and also decide on how to respond. E.g., Parking in a parking lot.

Human action recognition: Actions of pedestrians such as walking and running need to be recognized, so as to predict their actions, as otherwise their paths could intersect, causing accidents.

Vehicle localization and mapping: GPS location and positioning of the car is vital, as future cars shall communicate with each other for positioning on the roads, and for maintaining a safe distance from each other, as well as other features such as self-parking.

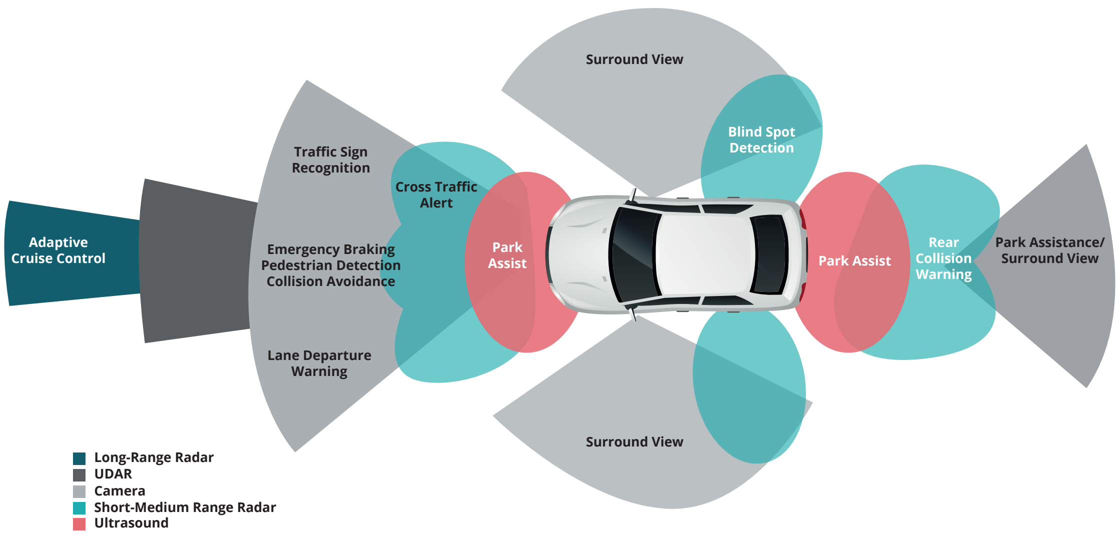
Platooning for driverless trucks: Autonomous driving will be expanded to all kinds of vehicles, including heavy transportation trucks, which will drive automatically without any driver assistance. Automated trucks will help in platooning of trucks, thereby maintaining the position of trucks with regard to each other, as well as increasing the capacity of the road.

How do Autonomous Cars work

Mediated perception approach

This approach involves multiple sub-components to recognize driving related objects, such as lanes, traffic signals, traffic lights, cars, pedestrians, etc. This recognition is made possible with the deep learning capabilities of the supercomputing chip, which is designed to process and label each object. The supercomputing board procures all the information from the sensors and processes it to analyze every possible scenario to take proper action. The final output space resides in a very low dimension, while mediated perception computes a high-dimensional world representation, possibly including redundant information and detecting a bounding box for a car, which is then used to estimate the distance to the car.

Autonomous cars use a number of techologies such as Camera, LIDAR, sensors and multi-domain controllers. Car manufacturers deploy their own technology to achieve different levels of automation in cars. Some organizations have their own understanding of how to employ such devices to improve automation in driving. Some of the standard devices that assist in autonomous driving are:



Camera	Multiple cameras around the car help the car to capture images of its surroundings.
Radar	Radio waves are transmitted and bounced off objects. The radar is useful for all weather conditions but cannot identify objects and most have issues with the resolution.

LIDAR	Light pulses are transmitted and reflected off objects. This can help in identifying lines on the road and also works in the dark. LIDAR is light-based radar that builds a continuously updated 3D scene model called a point cloud.
GPS	GPS helps in identifying the accurate position of the car.
Ultrasonic Sensor	This device is used to measure the proximity of vehicles near a car. It generates shockwaves by tuning a high frequency electric pulse and measures the intensity of the return signal.
Passive Visual	The usage of passive cameras and sophisticated object detection algorithms is meant to determine what is visible from the cameras.
Supercomputing Chip	It captures information from all the sensors, thereby helping to make quick and efficient flow of complex data through the vehicle, which is required to make automated features work well.

Players in Autonomous cars deploying Deep Learning

Original Equipment Manufacturers

Audi deploys assistive and automated capabilities across its product range with standardized zfas processors for its future models as well.

Partnering with Continental and ZF Lenksysteme, BMW aims to bring semi-automated features into its vehicles, and move towards highly automated vehicle technologies by 2020.

In 2017, the E-Class will be tested in Nevada. The vehicle has already been equipped with hardware that is capable of activating highly-to-fully automated driving and it requires only minor updates to the Drive Pilot Electronic Control Unit (ECU).

Mitsubishi Electric announced the technology to detect cognitive driver distraction based on deep learning algorithms, analyzing vehicle (steering) and driver biometrics (heart rate, facial orientation) time-series data, thereby warning drivers about potentially dangerous indications or conditions.

Nissan has announced its Intelligent Driving System (IDS) EV concept vehicle. It features Piloted Drive autonomous driving features that rely heavily on artificial intelligence.

Primarily focused on occupant and pedestrian safety, Volvo is likely to equip its entire product range with active safety and automated driving features by 2021. Its key technology partners include Bosch, Continental, and Quanergy.

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Tesla has developed a semi–autonomous feature called Autopilot, which updates certain features through crowd-collected data and helps in automatic steering, lane changing, and merging onto highways

Suppliers

The company is focusing on digital maps, image recognition, voice interfaces and AI, via the Baidu Brain autopilot, through the Baidu Institute of Deep Learning (IDL), while working with other OEMs.

NVIDIA makes its Deep Learning GPU Training System (DIGITS) available to scientists and researchers, enabling fast modeling and training for tasks such as image classification.

The company has developed sensor-agnostic control software for car autonomy, which is largely based on deep learning, while also including sensor fusion. It is in an early stage of development, so far focusing on mobility as a service vision, and has also begun operations in Singapore.

Bosch is developing its own hardware and prototype for autonomous cars (where they are radar suppliers for Tesla) achieving level 4 autonomy.

Continental is currently using driver analyzers to create predictive driver models that can decide the time required for a driver to take control of the vehicle's operation, an essential feature in highly automated driving.

Delphi Automotive was the first car company to complete a cross-country road trip using autonomous technology. The company is developing the next stage "vehicle-to-everything" (V2E) which allows vehicles to communicate with streets, signs, traffic lights, other cars and even pedestrians.

To meet the conflicting requirements of visual computing, Mobileye offers a System-on-Chip (SoC) solution that is capable of supporting a variety of applications such as collision avoidance and pedestrian detection.

TI's research is focused on enabling technologies, such as sensing devices of the likes of LIDAR and radar, high-speed data communication for sensor fusion applications, and enhancements in vehicle sensing and user interfaces, for autonomous driving.

FUTURE TRENDS

Market

Autonomous driving market will likely shift towards shared mobility solution, which could be the future of Transportation.A strong need to look beyond traditional sales models to strong leasing and shared mobility offerings, is vital to initially break into the market. Market entry time and access to user base are key here.

Technologies

There hasn't been a standard technology for autonomous driving yet which calls for more innovation and mass production to make affordable sensors such as LIDAR. Alternative sensing solutions such as active gating and HD mapping, along with centralized and GPU-based processing, are the technologies to look out for.

Product Focus

Autonomous driving will drive the market from a product-centric one to a service-driven one. The focus will add benefits and features to the car, such as modular seating, customizable add-ons, interactive interfaces, etc, to improve engagement and performance.

Software Defined Cars

Software will be the main focus in Autonomous cars, with regard to infotainment, Artificial Intelligence, etc. OEM and autonomous driving software companies are likely to collaborate with each other to create improved products.

Conclusion

Radical New Technology at Low Prices: Technology is evolving with regard to sensors and car connectivity, which will make it affordable for car manufacturers to install them in their inexpensive models as well

Faster Adoption with New Entrants: New players in the Autonomous driving space are driving innovation faster, such as Mobileye, NVIDIA, Delphi, Nutonomy, who are developing their own chips, software, etc.

New Mobility Concept: Interest in buying cars will gradually come down due to affordability issues and more shift will be seen towards shared mobility and car sharing programs

Evolving Industry: Traditional car manufacturers will no longer hold the largest share of profit as even suppliers of sensors and software are likely to compete in this market.

Rate of Innovation of AI: Development of Artificial Intelligence holds the key to bringing Autonomous cars into the open market

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