NEC's Commitment to Smart Mobility

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Abstract

Smart mobility, a new market centering around the auto industry, has led to dramatic improvements in safety/reliability, environment/ecology, and comfort/convenience made possible by equipping cars with smart technology and connecting them to the cloud. Related aspects of smart mobility include the development of autonomous vehicles and advanced driving support systems, as well as accelerating development of eco-cars such as electric vehicles and fuel cell vehicles. This paper discusses the issues that have affected the development of smart mobility (such as traffic accidents and environmental issues), public awareness and current problems, and society's efforts to solve these problems. Finally, we look at NEC's contribution to this market (image recognition technology, V2X communication technology, etc.).

Keywords

mobility, automobiles, in-vehicle, cloud, communications, network

1. Introduction: Issues Affecting Smart Mobility

The automotive environment has witnessed dramatic changes over the past few years. These include the need to reduce the number of traffic accidents, increased demand for environmental protection measures, and changing lifestyles. Automakers and parts suppliers are now under pressure to adapt to these changes.

1.1 Traffic Accidents

Globally, the automotive market has been driven by significant growth in China and India. This dynamic growth is expected to continue with annual auto sales estimated to break the 100 million barrier in 2018 (**Fig. 1**).

Unfortunately, more cars on the road means more accidents. The World Health Organization (WHO) forecasts that, among the top ten causes of death in the world, the number of road traffic fatalities - which ranked the ninth in 2004 with 1.2 million - will double by 2030 and traffic accidents will rank as the fifth leading cause of death that year.

Heavy traffic congestion and frequent traffic accidents are chronic problems in Asia's urban areas. Typically, the most common forms of car-to-car accident are rear-end collisions near intersections, sudden encounter collisions, and left/right turn collisions. Fatal accidents involving pedestrians often occur when crossing the street in front of or behind a stopping vehicle or when crossing the street and not using a pedestrian crossing. There are also an increasing number of accidents involving people over the age of 65 are involved.

In the United States, a New Car Assessment Program

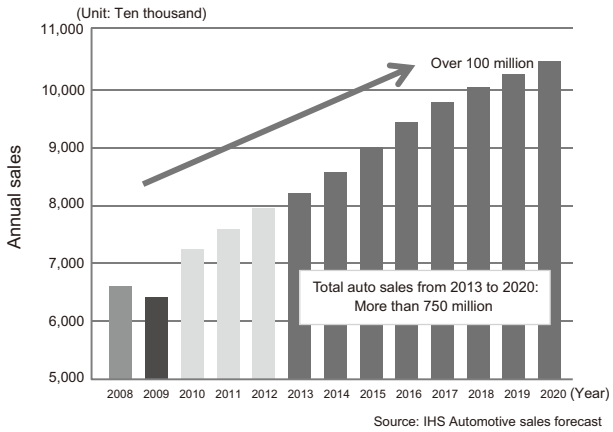

Fig. 1 Global auto sales forecast.

(NCAP) has been established to ensure the safety of cars (the European and Japanese counterparts are the EuroNCAP and JNCAP respectively). In Europe, the advanced emergency braking system (AEBS) and the lane departure warning system (LDWS) became mandatory for large vehicles in November 2013. In Japan, a similar AEBS became mandatory for buses and trucks in 2014. Also for passenger cars, the EuroNCAP added automatic braking to the evaluated items, making it a prerequisite for a high safety rating.

1.2 Environmental Issues

In 1997, the Kyoto Protocol was adopted, and Japan set FY 1990 as a reference year, promising that it would reduce greenhouse gas emissions by an average of 6 percent for the 5 years from FY 2008 to FY 2012. At this time, efforts to reduce carbon-dioxide emissions were accelerated in the mobility market, and all automakers have been increasing production and marketing of low-emission vehicles and fuel-efficient vehicles.

In Europe, the EU vehicle emissions regulations were established, and an ambitious goal was set aiming at reducing emitted gas from 120 g/km in 2015 to 95 g/km in 2021. In California, regulations for zero emission vehicles (ZEVs) such as electric vehicles and fuel cell vehicles have been stipulated. Due to these regulations, automakers who sell their cars in California are required to sell ZEVs as a specified ratio of their sales. This requirement is very strict - at 4.5 percent for 2018 models and 22 percent for the 2025 models - leaving the automaker with no choice but to meet these requirements as a prerequisite for access to the market.

Nonetheless, greenhouse gas emissions from traffic worldwide are on the rise, and the rapid increase of emissions in newly industrializing Asian countries is becoming a big problem. It is important to develop measures to deal with these growing emissions, as well as those from major emitters in the advanced nations.

1.3 Changing Lifestyles

Throughout the industrial world, the younger generation has been turning away from cars, a trend that is worrisome for automakers as it threatens the future of the industry. To win back young people, automakers have embarked on measures to make cars cool again.

Another problem is an apparent increase in the number of people with poor driving skills - especially among the younger generation. At the same time, the number of older drivers is increasing as the overall population ages. Also there are people who only drive to certain places (picking up and dropping off family members and driving to supermarkets, for example). And there are also people who have to drive even when they are very tired. With all these changes in people's lifestyles, the achievement of a comfortable in-vehicle space that allows drivers to drive at ease under any conditions has become more important than ever.

2. Public Awareness and Current Issues of the Smart Mobility Market

In this section we will look at public awareness of smart mobility, focusing on the perspectives of safety/reliability, environment/ecology, and comfort/convenience. We will also look at current issues and problems and suggest solutions.

2.1 Safety/Reliability

In the areas of safety and reliability, the smart mobility market is focusing on the development of the advanced driving assistance system (ADAS). Development of autonomous vehicles is also moving ahead quickly, with plans for coverage to be available on highways beginning around 2020, with later expansion to ordinary roads, and then city streets. Indeed, this marks the arrival of the smart mobility era, and with many international events in the offing in Japan, the coming years will provide numerous opportunities to promote the sophistication of the Japanese monozukuri* expertise to the world.

Autonomous vehicles require accurate positioning acquisition and high-precision sensing (recognition of moving objects, traffic signs, signboards, road ancillary equipment, etc.) in order to safely reach the destination from their present position. Positioning information is obtained from a GPS, but errors of a few meters can happen. There is also plenty of room for improvement in the sensing accuracy of the distance measurement, as well as in susceptibility to bad weather and available light.

Positioning acquisition and sensing accuracy are of vital importance for the comprehension of driving conditions and the generation of motion plans. If the accuracy is low, it could lead to a fatal accident. It is essential that technology is developed that has few errors and high accuracy. Also required is the installation of communication sites to facilitate the sensing of invisible areas. The construction of such social infrastructure is an issue on the national level.

2.2 Environment/Ecology

To address environmental issues, the smart mobility industry is implementing the development of clean energy cars, such as electronic vehicles (EVs), hybrid vehicles (HVs), and

* Japanese word that refers to manufacturing that fuses the values of traditional Japanese craftsmanship with future-oriented management and technology.

fuel cell vehicles (FCVs). As for vehicles powered by gasoline engines, manufacturers are introducing a steady stream of low-fuel-consumption vehicles - mostly compact cars.

As part of the response to the Kyoto Protocol, the distribution and transportation industry is working to reduce maximum speeds and improve transportation efficiency for large trucks on highways. These efforts are beginning to have an impact in terms of environment and ecology. On congestion-prone roads and roads with many traffic signals, the number of times drivers step on the brake and accelerator increases, thus increasing carbon-dioxide emissions. To mitigate this, measures to help drivers avoid congested routes are also being introduced.

In Japan, the highways are equipped with services that provide traffic conditions and safety information, including Vehicle Information and Communication System (VICS) and ETC2.0, which was formerly known as ITS Spot Service. These are also effective for traffic flow optimization.

With EVs, it is necessary to charge the battery when it is low. Although the number of installations of charging stations is increasing at car dealers, supermarkets, and convenience stores, they remain far too few. Besides a shortage of charging stations, the time required for recharging is also an issue.

It takes only a few minutes to refuel a gasoline-powered vehicle, which can run for several hundred kilometers on a full tank. An EV, on the other hand, has a range from 90 to 200 km when fully charged, but even quick charging takes about 30 minutes, while home charging can take up to 8 hours. Furthermore, battery deterioration is inevitable, meaning that electricity storage capacity gradually decreases as time passes after the purchase of the vehicle. To expand use of EVs, it is essential to build many more charging stations, reduce charging time, increase energy saving, improve battery performance, and establish accurate deterioration prediction.

Unlike EVs, FCVs only take a few minutes to refuel. However, as with EVs, there are few stations available that can refuel FCVs. Moreover, because they use hydrogen, some people worry about the potential for fire or explosions, making it important to counter this image and emphasize the safety of these vehicles.

Solving these problems will require both continuous technological progress and construction of social infrastructure.

2.3 Comfort/Convenience

Today, the public expects automakers to offer cars with a wide range of comfort and convenience features. Cars are no longer considered merely a means of transportation, but rather a comfortable and enjoyable moving space that reflects the driver's individual taste and preference. Efforts that have been made thus far include sporty car designs, interior car design to increase spaciousness, and automatic settings adjustable according to individual preferences.

Marketing services that distribute restaurant information, shop information, and scenic sites along the driving route, as well as entertainment services that offer music are part of this comfort and convenience enhancement. Automakers have developed systems to help drivers drive more safely and smoothly and to reduce bothersome operations. All of these changes are aimed at making driving more fun, while maximizing comfort and convenience.

One of the biggest factors behind all of these changes is the massive popularity of smartphones. People now expect and demand from cars the same operability and convenience that they get from their smartphones.

Needless to say, auto manufacturers and their suppliers are specialists in car making. To build an environment in which cloud communication is used, they have to build closer relationships with electronics manufacturers.

3. Society's Commitment to Solving These Problems

With so many dramatic changes in the market background, a paradigm shift is taking place in the auto industry. Conventionally, automakers and their suppliers play the key roles in the development and mass production of cars. From now on, however, we will see some very different players in this business.

Recently, in Japan, the term, "humanoid cars" has become popular. It's an expression that compares a car to the human body. Specifically, automakers and suppliers will be responsible for the limbs (vehicle control) while electronics makers will transcend the conventional framework and will be responsible for the eyes and ears (sensors), the nervous system (infrastructure), the face and mouth (human interface), and the brain (cloud and big data).

3.1 Trends of national projects

Approved by the Cabinet on June 14, 2013, "Declaration on the Creation of the World's Most Advanced IT Nation" declares that "the number of traffic accident fatalities will be reduced to less than 2,500 by about 2018" and "the world's safest road transportation would be created (the world's lowest rate of traffic fatalities compared to population) and traffic congestion will be greatly reduced by 2020."

Meanwhile, the Cabinet Office has launched the Strategic Innovation Promotion Program to promote research and development of automated driving technology and information communication technology. The program aims at the reduction of traffic accidents, improvement of driving comfort, support for transportation of vulnerable road users such as the elderly, elimination and alleviation of traffic congestion, and reduction of environmental impact. To facilitate future vehicle research, collection of a large amount of driving data is also underway.

3.2 Trends in the Auto Industry

As we discussed above when we mentioned "humanoid cars," automakers and suppliers will be responsible for development and manufacture of vehicle controlling systems - that is, the limbs. Generally, accelerators, steering wheels, and brakes are developed by automakers, while automated driving systems and ADASs are developed by suppliers.

In the area of vehicle control systems, automakers and suppliers do not need help from other industries. However, meeting demands for safety/reliability, environment/ecology, and comfort/convenience on the in-vehicle side, requires that they collaborate with electronics makers. It is hard to imagine that automakers and suppliers would attempt on their own to develop services that use cloud and communication technology.

3.3 Trends in the Electronics Industry

The conventional systems developed by automakers and suppliers are now collapsing. The connected car market, which includes automated valet parking and unmanned driving services, is expected to account for more than half of the automotive market in 2020, so the linkage with cloud and mobility capabilities will be indispensable. Furthermore, technology such as utilization of big data, which is not available in the conventional operations of automakers and suppliers, will be necessary. So it is obvious that the collaboration with electronics makers that have that technology will need to be strengthened.

Current in-vehicle control is activated with the maximum performance of real-time processing. When the genuine advent of autonomous driving and ADAS comes, the existing chips will not be able to deal with the volume of data and processing. In the near future, ultra-high-speed processing technology will be necessary, and the time will come when in-vehicle supercomputers will be obligatory. Because electronics makers have been conducting research into this technology and trying to turn it into products for many years, they have an advantage no other industry can match.

4. NEC's Contribution to Smart Mobility

As one of the world's leading electronics manufacturers, NEC is active in an extraordinarily diverse range of markets, executing research into a wide range of leading-edge technologies. Many of these technologies are applicable to the smart mobility market; in particular, image recognition technology and V2X communication technology.

4.1 Image Recognition Technology

Smart mobility involves three main functions that are constantly repeated: recognition, judgment, and operation. In other words, the system drives the vehicle while constantly assessing the surroundings in order to determine when to drive, turn, stop, and so on.

In order to assess the driving conditions and determine what action should be taken next, it is necessary to correctly recognize surrounding circumstances, in-vehicle conditions, and driver conditions, as well as the vehicle location (positional measurement). In particular, accurate recognition of the surrounding circumstances is critical to the achievement of safety/reliability. NEC has achieved all of this in the form of pedestrian recognition and traffic sign recognition systems, which we have developed after many years of extensive research (**Fig. 2**).

This technology is based on pattern recognition technology called generalized learning vector quantization (GLVQ), whose effectiveness has been proved in conventional OCR and face recognition systems. By integrating this with an identification system called learning kernel classifier (LKC) that uses an approach called "kernel trick," we have achieved high-precision recognition and high-speed capabilities.

In parallel with the above-mentioned technology, we are conducting research into danger prediction technology that uses machine learning technology, as well as recognition technology, to analyze camera images (visible light, single-lens) to determine the positional relationship between the vehicle and the traffic participants in its vicinity (pedestrians, passenger cars, buses, trucks, motorcycles, bicycles, traffic signals, and other objects).

Specifically, danger recognition is performed in the order of object detection according to each image frame, calculation of distance, direction, and speed, tracking of objects, assessment of traffic scenes, and judgment of dangerous situations (**Fig. 3**). Using this technology, the traffic conditions around the vehicle are captured as scenes with movements, and recognition and prediction of danger is possible based on the relative positional relationship between moving objects.

4.2 V2X Communication Technology

If a vehicle in an accident has stopped ahead of a curve in the road, in-vehicle sensors such as a radar and camera cannot

Fig. 2 Examples of pedestrian recognition (left) and traffic sign recognition (right).

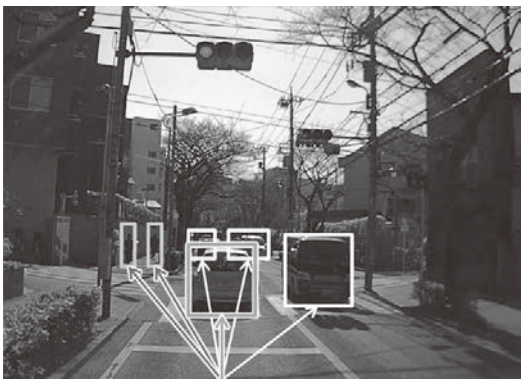

Fig. 3 Example of object detection.

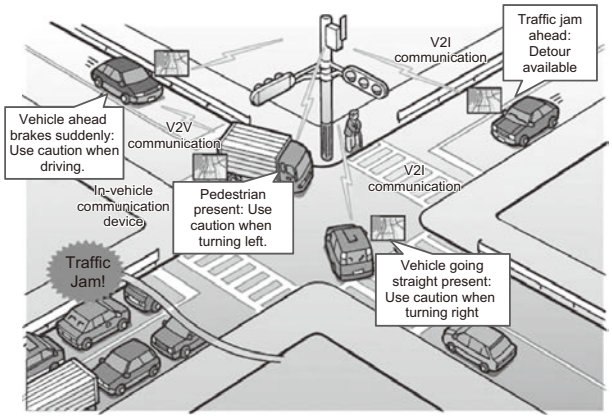

Fig. 4 V2I and V2V communications.

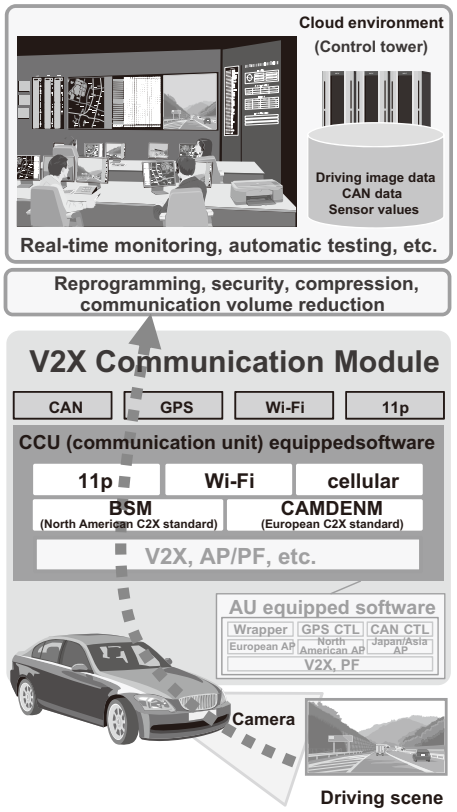

Fig. 5 V2X communication technology under development by NEC.

recognize its presence. In such a case, there is a high risk of an accident. Developing a means of sensing blind spots that cannot be detected by the in-vehicle sensors alone has become increasingly important.

To solve this problem, NEC uses two communication technologies: vehicle-to-infrastructure (V2I) communication in which information about accidents and other conditions is distributed from the road; and vehicle-to-vehicle (V2V) communication in which surrounding traffic information is mutually shared with other vehicles passing by each other (**Fig. 4**). These systems are called vehicle-to-X or V2X.

NEC has been conducting joint research into V2X with several European automakers since 2000. We developed a communication module using this technology and conducted verification tests. This system has been adopted as the European standard protocol.

NEC's V2X communication technology also offers superior congestion control. When communication is performed with multiple surrounding vehicles, radio wave interference occurs. To prevent this, NEC's system controls transmission electric power to prevent interference problems from happening.

As a further evolved version of the above-mentioned technology, NEC is currently developing a more compact communication module compatible with the North American protocol, as well as the European protocol. This is expected to be linked with the cloud environment, and we are planning to make it available as a solution that will be developed into a vehicle data utilization service using remote monitoring (**Fig. 5**).

5. Conclusion

In this paper, we have discussed NEC's leading-edge image recognition and V2X communication technologies and their application to smart mobility. In addition to technologies applicable to the auto industry, we also have many other advanced technologies from our Central Research Laboratories. By integrating these technologies, we will create solutions that offer new values, solutions that only NEC can offer, which we are confident will contribute to improvements in safety/reliability, environment/ecology, and comfort/convenience.

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