Toyo Tire's Vision of Technology for Next-Generation Mobility:
The possibilities opened by Tire Sensing
— How Far Will the Function of the Passenger Car Tire Advance? —
(Panel discussion transcript)

Speakers: Satoru Moriya, Corporate Officer for R&D Headquarters, Toyo Tire Corporation
Kazuhiro Sakakibara, Advanced Technology Development, Technology Development Division, Toyo Tire Corporation
Hideyuki Mori, Executive Officer, Solutions Headquarters, SAS Institute Japan
Yoshiaki Kawano, Manager, Japan / Korea Vehicle Sales Forecasts, IHS Markit

MC: We would like to hear your opinions on the sensing technology that has been announced by Toyo Tire. Allow me to start with our special guest Mr. Kawano's opinion. Mr. Kawano has been closely observing developments in the global automotive industry and issuing various forecasts. He is a top authority in the field with a great understanding of the changes in CASE. What is your impression of Toyo Tire's technology presentation?

Kawano: Tire sensing is an approach that perceives the tire itself as a sensing device. "Real-time visualization of tire force and communicating it to the driver" is a totally new approach we have not seen before. At the same time, I was impressed by the great speed with which technology is advancing. Among those who enjoy sports driving, there may be people who believe they are skilled drivers. However, it is a fact that driving skills change with the road conditions and the weather. In this respect, real-time visualization of tire performance and instantaneous communication to the driver leads to a greater sense of security and safety in driving. I believe this an area of great importance.

MC: Mr. Kawano has stated his opinion. How about you, Mr. Sakakibara?

Sakakibara: I want to ask one by all means first. Did the presentation spark your interest in our technology?

Kawano: I found it interesting. In the experiment video, the car was cruising on a wet surface in a closed circuit. In real situations when cars are driving on public roads or highways, the location of water puddles changes by lane. If a friction coefficient (μ) indicating a high risk of slippage is obtained for either the left or right tire and communicated to the driver, I feel it will be effective

for safe and secure driving.

Sakakibara: As specialists in the technology, we as a tire manufacturer are hoping to come up with something that is exciting for users. Because tire performance cannot be seen, we felt that we needed to show what kind of forces are involved. One example is to show the data to the car in numerical figures. However, we felt that we would be able to create new value by visualizing performance and so produced the concept visual by CG simulation.

MC: We just heard from our two speakers on visualizing tire performance, on visualization. However, I believe it is extremely difficult to actually visualize tire force and digitally present tire behavior and conditions because of the high speed of the tire rotation. How spectacular is it to make it come true? We would like to hear from Mr. Mori of SAS Institute Japan (hereinafter "SAS"), the collaborator in the development of this technology. Although I personally think that not everything can be done digitally, we would like to hear of the problems and challenges you have tackled in development.

Mori: Because I feel there are people who do not know our company, I would like to give you a brief corporate profile. We are a company that provides software to various industries—addressing issues such as reduction of risk and anti-money laundering in the banking industry, examination into the safety of clinical trials in the pharmaceutical industry and demand forecast for the distribution industry. Unlike other foreign vendors, we conclude contracts directly with our clients, providing consulting services and working together with the customer to come up with solutions. We have many data scientists who have very extensive experience and advanced technological skills to deliver solutions to our clients.

The idea of estimating tire force was a theme that we addressed for the first time. Much time was spent in gaining an understanding of what performance is demanded of the tire and of tire force. Another major challenge was mutual understanding. Furthermore, data gathered with IoT sensors is normally stored in the cloud and later analyzed as aggregate data. However, this research project was challenging in that information was gathered by an edge computing device installed in the vehicle and processed and fed back at the same time for the use of the data in some form or another. A challenge of this difficulty is something that our data scientists wish to tackle, and it became a popular theme that incited competition within the company. As the level of difficulty rises, the project attracts talented people. In this respect, it was beneficial for us in terms of stimulating excitement within our company.

MC: What is your opinion after hearing this, Mr. Kawano?

Kawano: In one of the CASE areas, that is, autonomous driving, there is effort being directed to vehicle driving that approximates human driving. This project by Toyo Tire is extremely important in terms of traffic accident prevention and safety. However, this requires the capability to process a tremendous amount of data. This will require the abilities and initiative of programmers and engineers to input the data. I believe such capabilities are in demand, both in terms of human resources and technology.

MC: There was the mention of challenge earlier by Mr. Mori. What do you think were the key points for the success?

Mori: Before getting to that, I must say that we began tackling the project from SAS gaining an understanding of the fundamentals—of what Toyo Tire wanted to do—before starting up the project to develop a model estimating tire force. In the course of the discussions, we gained an understanding of the true objective, that is, the importance of being able to make estimations on a real-time basis. Since we are a software vendor, we took pride in the fact that our strongholds are deep learning and edge computing mechanisms. An important point was that we were able to understand in the first stage of the project that what Toyo Tire wants to do is to estimate tire force. It was only because we had this understanding from the start that we avoided major setbacks, although we certainly had to grope our way forward through trial and error. It was very good that we were able to collaborate, not as client and vendor but as partners exchanging ideas.

MC: We would like to hear from Toyo Tire about what we have heard now.

Moriya: I was tremendously pleased to give a presentation to experts in sensing and other fields in the open sessions and attracting a great deal of attention. Sensing technology is something that is being studied by other companies. However, we believe that our company is a step ahead in establishing our concept. We feel that it is beneficial technology that will attract the interest of car drivers and also technology that will lead to a future mobility-based society.

Sakakibara: Although data analysis and AI are in fashion today, they are areas that involve an extremely high level of difficulty, with some companies unable to make effective use of these technologies. In such an environment, we believe that we were able to build this technology to this level because SAS and Toyo Tire were able to match ideas successfully. We feel this was made possible because of the successful alignment of what Toyo Tire wanted to do as a tire manufacturer with the technology policy directions at SAS.

Moriya: Our partner understood very quickly what we wanted to do. I am personally thankful to SAS

that research progressed so quickly, to the point that we were able to give a presentation.

MC: It was certainly a success achieved through collaboration. We are hearing buzzwords such as AI and deep learning a lot today. Mr. Kawano, how do you think they will change vehicle driving?

Kawano: There are two patterns in vehicle driving: autonomous driving and human driving. In an environment where road conditions change constantly, the tire, which is the only component of the vehicle that is in direct contact with the road surface, is the only means to provide road condition data input into the car in a massive quantity. If the tire is able to combine tire force and data visualization, there is a possibility of creating an advanced tire. The difficult point is that there is a difference in terms of riding comfort with various road conditions between human driving and autonomous driving. For this reason, our next research theme is to install tires with sensors on an AI-driven autonomous vehicle and to examine how to fill the gap (matters detected by the human senses between human driving and autonomous driving) with information obtained from sensors. There is also the matter of a change in the level of safety and security, caused by the degree of tire wear, friction and years in use. For this reason, another issue to be addressed is how to bridge the differences in driving depending on tire condition. In this respect, I felt that an extremely important step forward was made in the driving revolution with research advancing to the point of massive data processing and utilization.

MC: Next, we would like to proceed to the element of real-time processing as the key factor. I watched the test video at a tire proving ground shown in the technology presentation with great interest. Rain was falling in the video. However, tire performance will change if it has been snowing. I would like to know how many types of driving situations have been verified.

Sakakibara: Because of the various road surface conditions, all conceivable data needed to be gathered for AI learning. We have gathered data under various conditions. For your reference, we have prepared another test video. This was taken at the Saroma Tire Proving Ground. The measurement data was collected in the early part of last year. This video was taken for POC for measurement even on snow-covered roads and was utilized in improving estimation accuracy. The other video shows a test conducted at the Miyazaki Tire Proving Ground. The car was driven under conditions that closely approximated the limit in tire performance. Although there is no sound in the video, the tires were squealing. We are able to confirm the size of the circle, that is, the limit in performance, and rapid fluctuation in the dots, that is, the rapid change in tire performance, depending on abrupt steering. There are red dots and blue dots in the video. The red dots represent real measurements of tire force. The blue dots that appear to follow suit are tire force values that have been estimated by computation. We examined whether estimation

values approximated actual measurements. Gaining conviction as to the reliability of the tire force estimation model with the POC results, we gathered data on a variety of conditions including snow cover and high speed driving, and were able to arrive at our current level of technological advancement.

MC: What is your opinion, Mr. Kawano?

Kawano: Changes in road surface conditions take place around the world. Although there had not been much snow in the northern part of the US due to the warm winter weather this year, road surfaces have been wet and slippery for tires. In the experiment stage, Toyo Tire accumulated data using various vehicle models. Even when the same tire is used, there is a difference in tire performance, depending on whether the vehicle is a minivan, a hatchback or an SUV. I believe that assessment of tire behavior by vehicle model is highly significant. Among drivers of SUVs in the US, there are people who are overly confident about the performance of their SUVs. However, I have seen SUVs stalled at the shoulder of roads, such as highways and expressways, in areas with heavy snowfall.

I am under the impression that many two-wheel-drive vehicle drivers who are overconfident in the performance of their tires and cars are getting into trouble. SUVs and pickup trucks are generally believed to be four-wheel-drive but are not necessarily so. There is also the possibility of significant hazards, depending on road conditions, if the driver is not aware of the vehicle and tire conditions. In such a case, access to visualized information on tire force on a real-time basis will make the tire an important device in addressing the eternal issue of the safety and security of the driver.

MC: What do you think of the opinions of the other two guests, Mr. Mori?

Mori: The differences by vehicle model and by weather conditions have been mentioned. In actual driving, these conditions emerge in combination. The issue is what level of accuracy in computing is possible on a real-time basis. For high accuracy computing on each condition, many thousands and tens of thousands of estimation models of combinations of vehicle models and tire types must be managed. The issue is how to strike a balance between the management of massive amounts of data and accuracy.

Moriya: At present, we have collected data only at our tire proving grounds. It will be interesting to know what results will be obtained if a variety of data is gathered by driving on public urban roads. We wish to improve mobility safety by increasing estimation model accuracy.

MC: We have understood that Toyo Tire is obtaining solid results on the commercial application of its sensing technology through experiments. In the technology presentation, we saw a CG image video that simulated tire force. The image resembled a scene from a videogame. I was able to feel a game-like sensation of driving a car from the video. Was the concept of the video inspired by games?

Sakakibara: That is a simulation video created with computer graphics. In e-sports, the tire force of the tires can be seen on the game screen. We were inspired by the inverse idea of "what if tire force was measured in actual driving?" That was actually an important clue in technology development. We believe that our success in collaboration with SAS lies in this video helping in aligning the direction of our technology development. We were able to accelerate development because SAS and our company agreed on the common understanding that our research direction is to be "expression of tire force in circles and dots", that is, tire performance.

Moriya: In Japan, interest in driving cars is shrinking. For example, let us imagine a child is on the passenger side and sees the drive status of the car on the panel. We may be able to stimulate an interest in driving cars and prevent the loss of interest in motor vehicles. At the same time, however, we would like to assure safety, alongside the element of entertainment, with technology. I feel like this technology will be an interesting and exciting system.

MC: Speaking as an amateur, it will probably be a learning experience regarding safety. If tire force that is actually invisible becomes visible, I think that it will help those learning to drive at driving schools.

Moriya: For example, the yellow circle expanding outward suggests that the tire's grip force is approaching its limit and is becoming vulnerable to slipping. It will be easier to see the extremely hazardous condition that the car is in. It can certainly be used in driver education at driving schools.

MC: For a person who just started driving, there are anxieties when driving under real conditions. I feel like it would be beneficial to grasp what driving is about beforehand with simulation CG. It was an extremely interesting video.
In the presentation, it was said that advances in sensing and other tire technologies will be able to supply various forms of "excitement" (benefit) to people. What kind of future will this technology realize in the future mobility-based society?

Moriya: As I said earlier, we consider vehicle security and safety to be an important theme. Various projects are underway today to assure vehicle safety, such as avoidance of emergencies by driver

braking and sensors installed on vehicles. With advances in autonomous driving, the only elements that will contribute to safe driving will be vehicle control and the tire. Since the tire is the only part of the vehicle in direct contact with the road surface, it is an important device in assuring safety. For this reason, we plan to develop technology by utilizing this distinctive characteristic. Future tires are expected to fulfill their role as a component of the motor vehicle that assures safety, amid advances in autonomous driving in the motorized society. We hope to contribute to society through this approach in tire manufacturing.

MC: What is your opinion on the potential of this technology, Mr. Kawano?

Kawano: As Mr. Moriya mentioned, autonomous driving will be an element to be taken into account. With the wider use of shared cars in car sharing and rentals under CASE, the vehicle used by the driver will not always be the same one. The driver will not be able to choose the vehicle or the tires for the vehicle used yesterday or for the vehicle used today or tomorrow. There is also the matter of differences in driver skills. Through greater visibility of the tire conditions for each vehicle, in the way visualized by Toyo Tire technology, it is good to be able to be aware how dangerous one's driving is based on the road and tire conditions.

MC: For Toyo Tire, I believe the third-party perspective is important in giving concrete form to the business vision for tire sensing technology. In what area of business do you feel you should find collaboration partners in order to create the future?

Sakakibara: We have a total business concept that we have envisioned as a tire manufacturer. We need to build in model data for estimating tire performance with an edge computing device installed on board the vehicle and to have the entire process from data-gathering to tire force estimation executed within the vehicle. Furthermore, we are considering creating a cycle of uploading necessary data from the edge computing device for further improvement in the added value of the tire.

In creating this system, we need to find a partner who will engage in technology development with Toyo Tire. If this is extended to data utilization, management, monitoring and connectivity, we believe that this tire force will have value as data. As mentioned in the presentation, the combination of accumulated tire slip data with the map will help create a map of hazardous locations for driving. From the standpoint of vehicle management in car sharing services, drivers who practice eco-friendly driving, for instance, may be rewarded with loyalty points. There is also the possibility of utilizing driving data in insurance services. These are all coming strictly from my own imagination. I expect to see the use of tire force as data in a variety of collaborative work, presenting various business opportunities and generating added value.

MC: Do you have ideas on collaboration, Mr. Moriya?

Moriya: Since we are a tire manufacturer, the new business model will require collaboration in regard to sensors, etc. Toyo Tire hopes to make its contribution as a single component in creating the foundation of a safe and secure mobility-based society and in bringing happiness to customers.

MC: The future is looking more exciting. What is your opinion on the potential of this technology, Mr. Kawano?

Kawano: In addition to the tire's basic functions of running, stopping and turning, the technology will create the new added value of "thinking, connecting and accumulating data" in the tire. Furthermore, there is potential for increasing the value of the motor vehicle through a new synergistic effect. The technology holds promise not only for installation on new vehicles but also for application to replacement tires in the after-sales market. The potential is likely to expand in scope with technological application to the huge number of vehicles owned by people around the world. The system will be able to utilize data, feedback road conditions and communicate tire and road surface conditions to the driver. In addition, the accumulated data can be fed back to administrative authorities for collaboration in traffic control, such as sharing locations with hazardous road conditions.

MC: We were able to listen to a very interesting talk regarding the potential for mobility that is likely to be realized in the near future. With the visibility of tire performance, we are able to see the development of a new mobility-based society. I look forward to greater advances in tires at Toyo Tire.

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