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? —
(Q&A session transcript)

Q: Is it correct to understand that tire grip is effective when the dot (showing the current condition of grip force) is inside the circle (pointing to the limit of tire force/grip force)? Please inform us of the distinctive characteristics and functions of the circles and the dots. (See Slide 18)

A: The dot in the circle represents the change in grip force based on vehicle steering, acceleration and braking. If the dot is located near the center of the circle, it suggests normal driving conditions. It is a neutral image of driving. With acceleration, the dot moves upward to transmit force to the tire. When cornering, tire force moves in the direction opposite to the direction of the corner. The circle on the outside shows friction. On an icy road, the conceptual image is a reduction in circle size.

Q: Will loss in grip move the dot outside the circle?

A: Decline in grip reduces the size of the circle. The circle shrinks in size, for example, on a rainy day with tires that are worn and have no grooves.

Q: Where are the sensors located?

A: In this presentation, the sensors are located on the tires. We are presently investigating various locations for sensor installation in order to make this technology a reality. Installation on the inside of the tire demonstrates outstanding sensitivity, due to the direct input from the tire. However, a very high level of technical difficulty is involved when installing a foreign object inside the tire. We are considering the installation of sensors in TPMS. We have not yet decided on the location of the sensors.

Q: When will it be commercialized?

A: We have already created the estimation model. However, there are issues that remain regarding module development. We are searching for partners for collaboration in this area.

Q: Is the image of this tire force estimation model similar to the G sensor (acceleration sensor) that covers the conditions of all four wheels and the vehicle?

A: The G sensor shows data for all four wheels as a single car. What we are planning, however, is to produce tire force for each tire.

Q: Is it correct to understand that tire force shows numerical values for the tire force of a single tire?

A: That is correct. There is a shift in load between the right tire and the left tire when cornering. This will result in a change in the size of the circle and movement of the dots.

Q: Is it correct to understand that tire force is shown for each tire and that the tire force changes with tire location (front/back and left/right)?

A: Yes, it is. Sensors are installed in each of the four tires. The tire force display is processed for each tire.

Q: There are many factors involved, such as vehicle model and vehicle weight. Is your approach in thinking to estimate tire force through AI analysis regardless of these factors?

A: We are assuming actual implementation of general-purpose data. We are gathering data under different conditions, such as size, vehicle, category, etc. We are building a program that covers all such factors.

Q: What is being detected by the sensor and how is tire force evaluated?

A: We base tire performance on axle force. We identify the friction coefficient μ of the tire from them and use it in computing. Internally, they are being shown as circles and dots with considering in type of road surface, road surface condition, tire condition, etc.

Q: Are MEMS sensors used?

A: We have not used them this time. We are considering the use of MEMS as an alternative in the future.

Q: Does the sensor detect pressure and G?

A: That is correct.

Q: In the discussion, an example of display was shown. What type of display is being envisioned for the future? (See Slide 6)

A: This time, we thought that there is value in presenting this on-screen. It is a conceptual image of the driver recognizing their own driving conditions and tire usage with the display. Showing it on the display is a means of visualizing the system. In addition, the data can be connected to vehicle control, rather than shown as an image. If ESC, ICS and ABS are able to detect tire conditions, they will be able to function with greater accuracy. What we would like to achieve is visualizing, including the user alert function, sense of fun and entertainment.

Q: ABS, ESC and others are being used for vehicle control. Are you thinking of synchronizing tire force with ABS and ESC? The G sensor shows no change in the circumference of the circle but how much distance remains with the circle. In the test drive movie, the circle diameter changed on snowy and wet surfaces. We can understand that the grip force changes by road surface. However, there was a change in circle size and dot location even on a dry surface. I thought it was difficult to understand with the change in diameter and in dot location.

A: The movie showed the results for one tire only, which may have invited some misunderstanding. When steering, the load direction changes for the right wheel and the left wheel. The influence of this load is shown in the size of the circle. With a greater load, the circle grows in size. With less, the circle shrinks. If all four tires are shown, as in the first CG footage, you would have been able to see the shift in load from wheel to wheel.

Q: Are you considering coordination of action with the vehicle?

A: We are considering as one of the possibilities. Not only use in vehicle control, but also, we are thinking of more data use applications. For example, the data can be combined with maps to identify locations where tires actually slipped. If data on hazardous surfaces are gathered through connected cars, we believe we may be able to share the information to drivers traveling on such roads.

Q: Will the information provided to users be data on the four tires?

A: Yes, for all four. However, there will be people who want to know the tire force for the entire vehicle. We are hoping to be able to choose an option on the system at the request of the user.

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