Development of Next Generation Multi Angle Vision™(New screen,compact and lightweight)

Takumi YOSHIMOTO Kouei KIYO Yoshitsugu YAMASHITA

Abstract

Recently, a fitting rate of on-vehicle camera has increased as a supporting device of safe driving for drivers. A fitting rate of surround view system (four cameras) which helps not only visual support for vehicle's rear but also safety confirmation around the vehicle has increased rapidly. We, DENSO TEN commercialized the world's first 3D-view system with "three-dimensional virtual projection viewpoint technology" as Multi Angle Vision™ in 2010. TOYOTA Motor Corporation adopted our system and has been proceeding with installation to various vehicles as Panoramic View Monitor.

With the spread of system, the requirements for safety confirmation around the vehicle become high. Not only conventional panoramic view images of the vehicle but also the proposal for new screen system adapting to driving scene is required by users and customers.

At this time, we introduce new screen utilizing 3D-view which is adopted for the next generation Multi Angle Vision™ and working on the compact and lightweight.

1. Introduction

In recent years, the fitting rate of on-vehicle cameras to support safe driving for drivers has been increasing, and the fitting rate for surround view systems (four cameras), which help not only visualize the vehicle's rear but also confirm the safety around the vehicle, has also rapidly increased.

In 2010, we commercialized the world's first 3D-View system with"3D virtual projection viewpoint technology" as the Multi-Angle Vision™, which has been adopted by Toyota Motor Corporation and is being fitted to various vehicles as a panoramic view monitor. However, with the spread of these systems, the requirements for safety confirmation around the vehicle are also increasing. Innovations are required not only for conventional overhead view images of the vehicle but also for screen systems adapting to the driving situation.

It is also necessary to respond to environmental changes such as improving fuel efficiency, and ensuring mounting space following increased electronic devices.

We have developed a next-generation Multi-Angle Vision™ which aims to adopt a new screen fit for confirming safety around the vehicle while also being compact and lightweight. In this paper, we present a description of our efforts.

2. Adopting a New Screen

Factors leading to the functional development of this next-generation Multi-Angle Vision™ were the higher resolution in displays and the advancement of safety equipment.

The conventional Multi-Angle Vision™ used a 7 to 9 inch display, but this time we were able to fully render images in a wide, 12.3 inch display, making use of the spacious display space.

The peripheral systems linking with Multi-Angle Vision™ have also become more advanced, such as addition and functional improvement of safety equipment and sensors including the clearance sonar and the cross-traffic alert / pedestrian detection rear camera.

With the expanded display space and increase of linked safety equipment, the amount of information to be notified to the driver has extremely increased. Therefore, with the next-generation Multi-Angle Vision™, we began functional development aiming at an intuitive, easy-to-understand HMI while suppressing the amount of information.

2.1 Side Clearance View

"Dual-side view" was adopted in conventional models as a screen for supporting passing through narrow roads, but only the area around the front wheels was shown, and it was difficult to tell at a glance what part of the vehicle was shown until the driver got used to it **(Fig. 1)**.

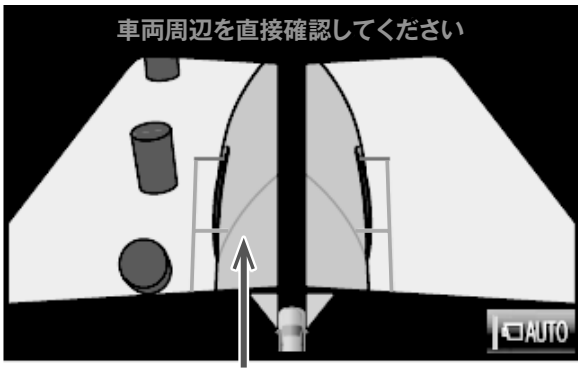

Fig. 1 Conventional Dual-side View

For the side clearance view, we developed a screen that adopts a 3D projected overhead view image, as if looking down at the car from above the rear, and allows the driver to easily grasp the vehicle width and confirm the side clearance. It is now easier to intuitively understand the clearance to the left and right, such as when running off the shoulder of the road or passing opposing traffic on narrow roads **(Fig. 2)**.

Fig. 2 Side Clearance View [1]

2.2 Cornering View

When checking traffic from the rear to prevent a collision accident and checking if the vehicle not to run up on the curb or the like upon turning at an intersection or narrow road, conventionally, it was necessary to look at the overhead view image. However, the display size was small and it was difficult to confirm. In this situation as well, we made use of 3D-View's features and investigated a display that makes it easy to intuitively understand the car curb on a screen where the driver looks down on the vehicle from the side-rear. At first, with the rear perspective, there was an issue in which the vehicle graphic hid the road under the edge of the vehicle, making it impossible to confirm the outline of the vehicle **(Fig. 3)**.

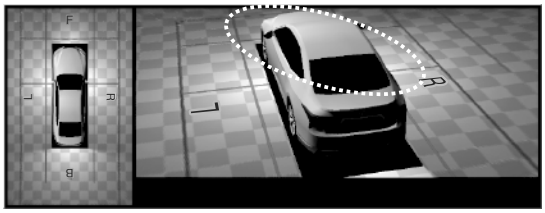

Fig. 3 Cornering View: Initial Development

To solve this issue, we included a display that used gradation to make the section where the vehicle graphic and the road under the vehicle edge overlap transparent. We developed a new display method that allowed the user to grasp both the shape of the vehicle and the road status near the vehicle edge, and this screen made it easy to confirm the vehicle surroundings, such as traffic from the rear when turning or driving through tight turns on narrow roads **(Fig. 4)**.

---

*[1]Toyota Motor Corporation, Toyota Global News Room
https://newsroom.toyota.co.jp/jp/detail/18859440

Fig. 4 Cornering View: Adopted Screen[(2)]
(With vehicle gradation)

2.3 Sensor-Linked Display

To match the addition of safety equipment fitted in the vehicle and their improved performance, we also improved the display method for linked display with Multi-Angle Vision™.

2.3.1 Clearance Sonar Harmony Display

By increasing the number of sonar sensors (from 6 to 8) and improving the obstacle detection performance, we changed the icons that were conventionally displayed superimposed on the vehicle in the overhead view image **(Fig. 5)** to be displayed matching the location of the obstacles on the street **(Fig. 6)**.

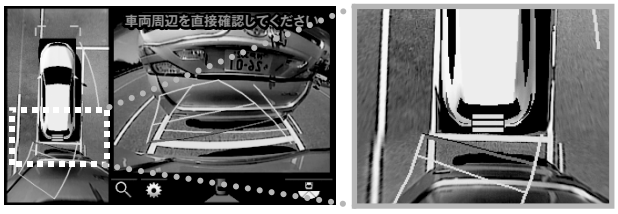

Fig. 5 Conventional Clearance Sonar Harmony Display

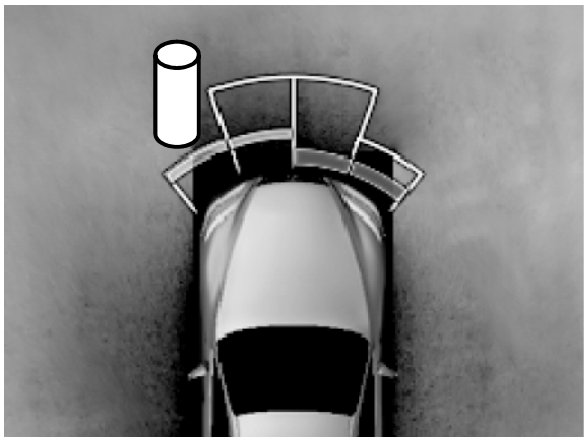

Fig. 6 New Clearance Sonar Harmony Display (Overhead View)

In the diagonal-perspective cornering view, the sonar icon is expressed as a semi-transparent wall-type, making it easy to intuitively understand the location of the obstacle in the image **(Fig. 7)**.

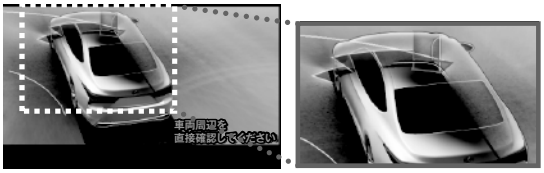

Fig. 7 New Clearance Sonar Harmony Display (Corning)

2.3.2 Cross Traffic Alert Harmony Display

In linkage with the cross traffic alert, which notifies the driver of approaching vehicles from the vehicle side, we adopted a display method that sequentially lights up three arrow icons to make the direction of approach easier to understand **(Fig. 8)**.

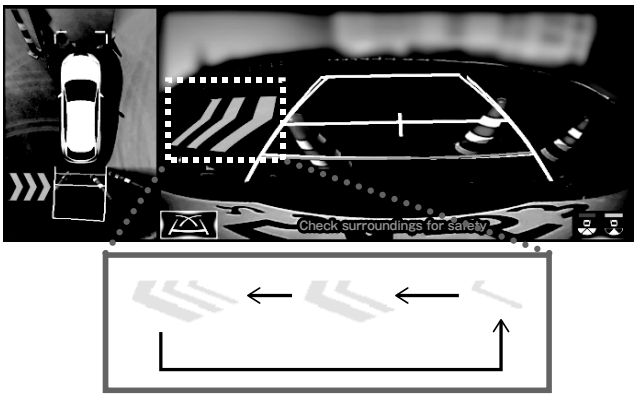

Fig. 8 Cross Traffic Alert Harmony Display

2.3.3 Parking Support Brake Harmony Display

A support brake function is equipped in the vehicle; wherein the vehicle automatically applies to brake based on information of detected obstacles or approaching vehicles / rear pedestrians from multiple sensors. In order to link with the brake function and convey the situation to the driver when the support brake is operating, we made the display showing the operating status larger on the Multi-Angle Vision™ screen. **(Fig. 9)**

---

*(2) Toyota Motor Corporation, Toyota Global News Room https://newsroom.toyota.co.jp/jp/detail/18859440

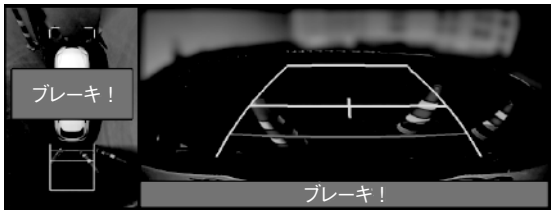

Fig. 9 Parking Support Brake Harmony Display

3. Efforts for Compact and Lightweight Products

3.1 System Outline

The following shows the system configuration of the next-generation Multi-Angle Vision™ **(Fig. 10)**. Images from the four on-vehicle cameras mounted to the vehicle are loaded into the Multi-Angle Vision™ via NTSC signal, and processed by ASIC and the microcomputer, then output using GVIF to display them. Also, necessary vehicle signals such as the shift position are loaded into the Multi-Angle Vision™ through CAN communication.

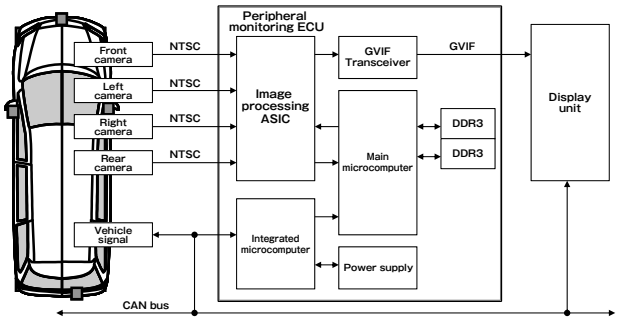

Fig. 10 Next-generation Multi-Angle Vision™ System Configuration

3.2 Downsizing Technology

To achieve high resolution, support for the wide display, and high-definition rendering performance, we adopted high-performance microcomputers and DDR3 memory, resulting in a more compact product with the rendering performance approx. 1.3 times more.

Continuing to stick to the concept of functional safety of the conventional Multi-Angle Vision™ system, wherein the operation of the main microcomputer, which performs 3D rendering, is monitored by another microcomputer and the image quality of camera input/output is monitored by ASIC, we also implemented the following to achieve a more compact, lightweight Multi-Angle Vision™.

① Microcomputer integration: Conventionally, the CAN communication function and power supply control/monitoring function, and the main microcomputer monitoring function were realized using two microcomputers, but we performed function aggregation to integrate them into one microcomputer.

② Compact ASIC development: Based on the image processing ASIC developed in FY2012, we expanded functions for high-resolution display while reviewing all the conventional functions, removing any unnecessary functions and unnecessary terminals. As a result, we reduced the package size to approx. 70%.

③ Adoption of all-reflow: We adopted low-profile, space-saving SMD connectors for the vehicle connectors and GVIF connectors, and replaced all DIP parts that were used in the power circuits and the like with SMD parts. By adopting compact parts, it became possible to mount each function block at high density, cutting the mounting surface by approx. 25%.

Through the above efforts for more compact, lightweight products, we successfully reduced the product size by approx. 40% and the mass by approx. 30%. **(Fig. 11, 12)**

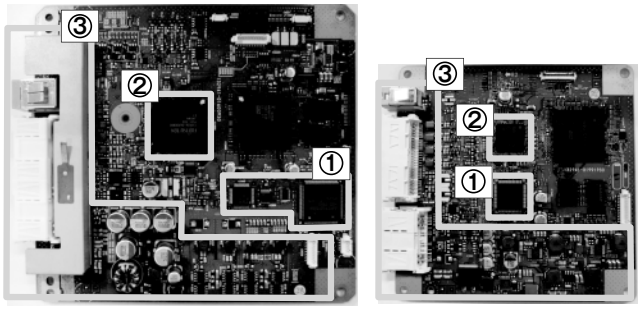

Fig. 11 Substrate Layout
(Left: Current Product, Right: Developed Product)

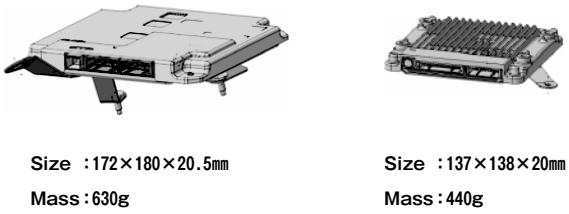

Fig. 12 Product Size
(Left: Current Product, Right: Developed Product)

4. Conclusion

Here, we introduced our efforts for a new display method using our strength, the 3D-View, as well as for more compact, lightweight products. Having achieved this, the next-generation Multi-Angle Vision™ was adopted for Toyota Motor Corporation's LEXUS LS, which went on sale in October, 2017.

In order to support self-parking and autonomous driving, which we expect will spread rapidly in the coming years, we are engaged in raising the resolution of camera images and developing image recognition technology for obstacles, hoping to contribute to the development of driving support systems that not only confirm the safety of the surroundings but also give the driver a greater sense of security.

Lastly, we would like to express our heartfelt appreciation to everybody at the Toyota Motor Corporation, Advanced Safety System Development Div. No.2 System Development Dept. No.22, who strove for commercialization.

Image source: **(Fig. 2, 4)**
Toyota Motor Corporation: LEXUS LS SAFETY
https://lexus.jp/models/ls/features/other_safety/

Profiles of Writers

Takumi
YOSHIMOTO

VICT Engineering
Group Engineering
Dept.4

Kouei
KIYO

VICT Engineering
Group Engineering
Dept.4

Yoshitsugu
YAMASHITA

VICT Engineering
Group Engineering
Dept.4