Automotive Graphics SoC for 360° Wraparound View System

● Suehiro Kawanishi

Recently, camera systems have been evolving to assist the vision of automobile drivers and reduce their blind spots around a vehicle. The 360° wraparound view system developed by Fujitsu Semiconductor allows the driver to freely change the point of view to zoom in on a desired area by projecting an image on a 3D curved surface. This makes it possible for the driver to identify vehicles and pedestrians in the surrounding area, which was difficult with the existing overhead camera systems. The 360° wraparound view system has been developed by using graphics systems-on-a-chip (SoCs) for in-vehicle use (MB86R11/MB86R12). These SoCs combine ARM's Cortex™-A9, integrate an OpenGL ES2.0-compliant graphic engine and various peripheral interfaces on one chip, and achieve a low delay of 30 ms from camera image capture to composite image output and high image quality with a processing function to improve visibility. In addition, the middleware and authoring tools for creating and editing full-perimeter 3D monitoring images have realized a 360° seamless view around a vehicle. This paper gives an outline of the 360° wraparound view system and an explanation about its development platform.

1. Introduction

Recently, camera systems have been evolving to assist the vision of automobile drivers and reduce their blind spots around a vehicle by installing cameras including a back guide monitor on board. As vision assistance by means of multiple cameras, overhead camera systems that synthesize four camera images to display images of the area surrounding the vehicle have been commercialized. However, these systems are only capable of showing overhead images and had a problem in that drivers could not sufficiently identify vehicles and pedestrians in the surrounding area with them. To solve such problems, Fujitsu Semiconductor has developed a 360° wraparound view system as a technology for offering to the driver appropriate view images according to various driving situations.[1)–3)]

This paper first gives an outline of the 360° wraparound view system and an explanation about its development platform. Then, the actual situations of use and approaches to improvement of image quality are described.

2. Outline of 360° wraparound view system

To ensure safety, drivers need to quickly check their view according to various driving situations including parking, turning right or left and merging. For that purpose, they make full use of various mirrors including the rearview mirror and right and left side mirrors and also vision assistance systems such as a back guide monitor, in addition to making visual checks. However, the burden placed on drivers in terms of checking the field of view is not sufficiently mitigated because the information they obtain from their field of vision is not integrated.

To solve this problem, we have developed a 360° wraparound view system that can use a monitor to display images of the entire perimeter of the vehicle from an arbitrary point of view and smoothly shift the point of view when the display content is switched between different images.

An overhead camera system, which is an existing technology, converts images captured with four cameras mounted on the front, rear, right and left sides of a vehicle into overhead images as seen from directly above the vehicle and synthesizes them on a screen to show the driver [**Figure 1 (a)**, **(b)**]. In comparison, the 360° wraparound view system adopts the "3D virtual projection/point of view conversion technology." This technology uses images captured again with four cameras mounted on the front, rear, right and left sides of a vehicle, synthesizes them to project an image on a virtual 3D curved surface, and converts it into an image as seen from an arbitrary point of view. While the system uses images captured with four cameras in the same way as an overhead camera system, it is capable of displaying a desired image from an arbitrary point of view after point of view conversion. This results in an image after composition that is significantly different from that with the conventional technology [**Figure 1 (c)**]. The image is projected on a 3D curved surface, which means the areas assigned to individual image pickup devices do not grow extremely large even if the distances from the vehicle become long. Furthermore, we have used the "point of view interpolation technology" to allow smooth transition of the line of sight when the driver switches the display content between different images. By interpolating the point of view, line of sight direction and view area for display before and after the point of view switching, the drivers can instantly recognize in what direction they are looking at the vehicle, which mitigates the burden on the drivers in checking the field of view.

3. Development platform

This section describes the graphics SoCs for in-vehicle use, which has provided a development platform of the 360° wraparound view system, 360° wraparound view middleware and authoring tools.

3.1 Graphics SoCs for in-vehicle use (MB86R11/MB86R12)

In the 360° wraparound view system, four camera images are captured and subjected to multiplexing while synchronization is maintained. Then, an SoC for in-vehicle use (MB86R11/MB86R12) takes charge of synthesis of the 360° wraparound image (**Figure 2**). These SoCs have Cortex™-A9 of ARM, a British company, as the processor core and integrate on one chip an OpenGL ES2.0-compliant graphics engine, video processing circuit, memory circuit, YUV inputs that accept direct input of four camera images and various peripheral interfaces for in-vehicle use (**Table 1**). They have achieved real-time operation with a low delay of up to 30 ms from the capture of four camera images to composite image output and high image quality by means

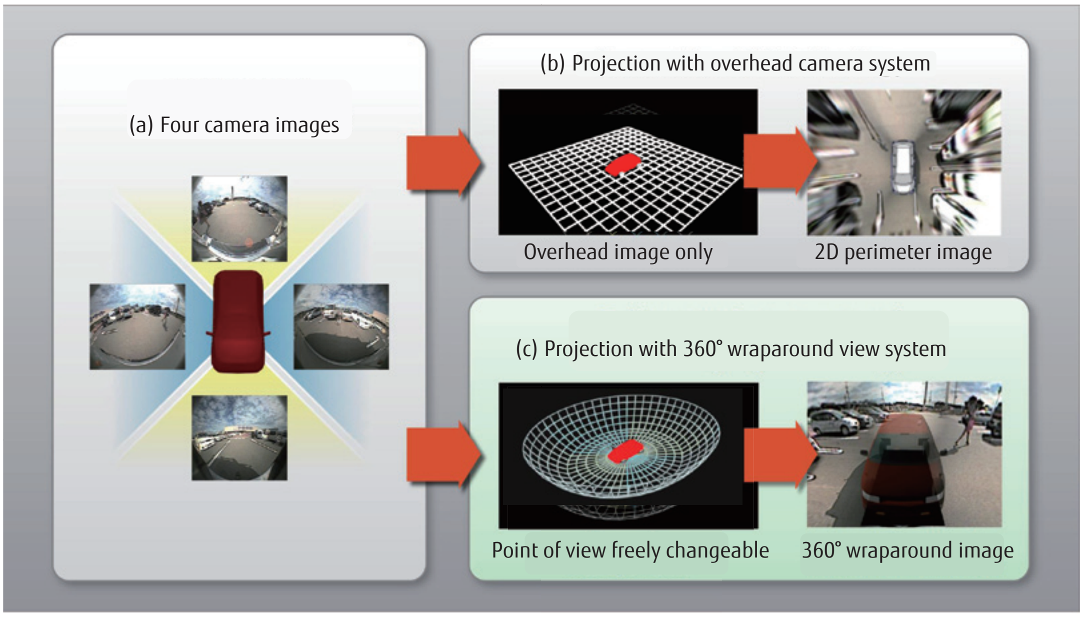


Figure 1
Comparison of projection methods.

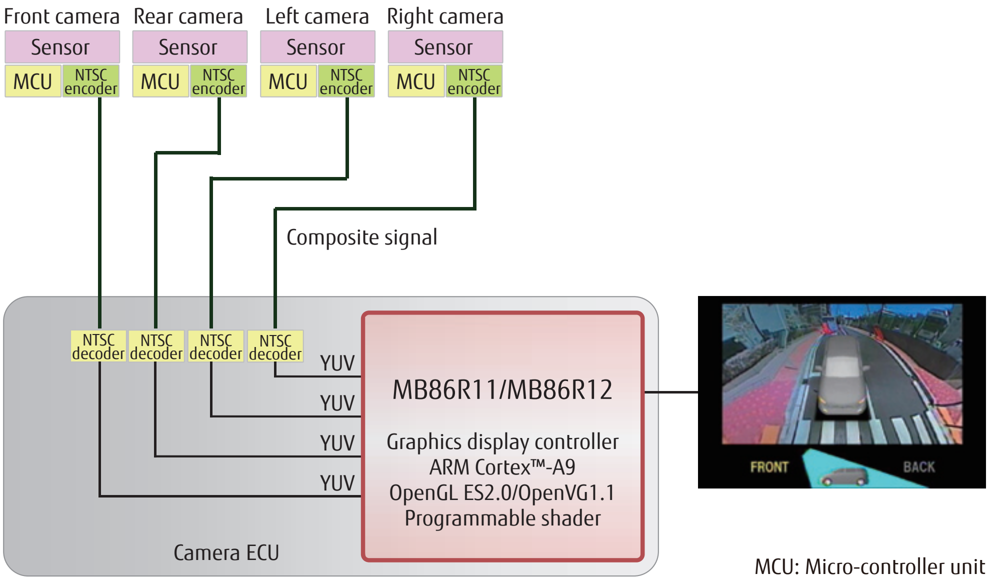


Figure 2
System configuration for 360° wraparound view.

Table 1
Major specifications of MB86R11/MB86R12.

Item	MB86R11	MB86R12
Process technology	CMOS 65 nm	Same as on the left
Operating voltage	Internal circuit block: 1.2 ± 0.1 V I/O block: 3.3 ± 0.3 V DDR3: 1.5 ± 0.1 V/DDR2: 1.8 ± 0.1 V	Same as on the left
CPU operating frequency (max.)	ARM Cortex™-A9 400 MHz, NEON	ARM Cortex™-A9 533 MHz, NEON
Graphics	OpenGL ES2.0-compliant Unified programmable shader function 2D drawing function, 8-layer overlay, Dithering, gamma correction Video output (max.): 1600 × 1200, DRGB/RSDS, TCON Video input (max.): 1280 × 720	Same as on the left
Peripheral I/O	USB2.0 Host/Function, USB2.0 Host, SDIO/MMC, 12-bit A/D converter, I^2C (I/O voltage: 3.3 V), CAN (I/O voltage: 3.3 V), MediaLB (MOST25/50), USART/UART, GPIO, SPI, Quad SPI, I^2S, PWM, IrDA (Ver.1.0), TS I/F, Ethernet link, IDE66 (ATA/ATAPI-5)	APIX2, SDIO/MMC, 12-bit A/D converter, I^2C (I/O voltage: 3.3 V), CAN (I/O voltage: 3.3 V), MediaLB (MOST25/50), USART/UART, GPIO, SPI, Quad SPI, I^2S, PWM, IrDA (Ver.1.0), TS I/F, Ethernet link, IDE66 (ATA/ATAPI-5)
Operating temperature range	−40 to +85°C	Same as on the left
Power consumption	1.8 W (typical)	2.0 W (typical)
Package	544-pin PBGA	544-pin TEBGA

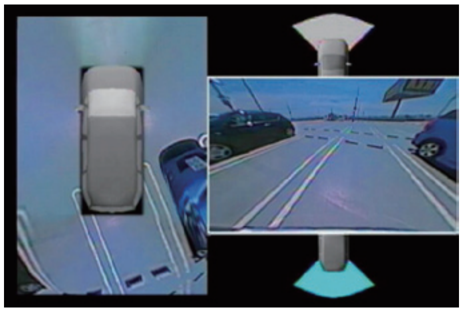
of the visibility enhancement processing function.

3.2 360° wraparound view middleware and authoring tools

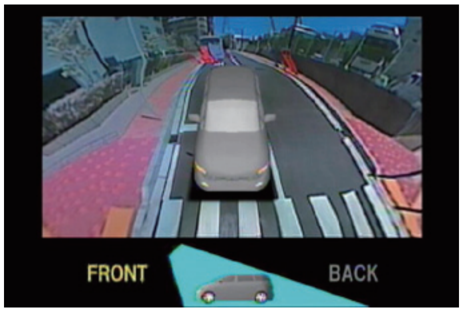
The software library that constitutes middleware for a 360° wraparound view system conforms to OpenGL ES2.0 and is responsible for drawing the 3D images that are required for creating 360° wraparound view images. The Visibility Enhancement Unit (VEU) and Graphics Display Controller (GDC) drivers are also included in the middleware (**Figure 3**). In addition, authoring tools for creating 360° wraparound view images from various perspectives are also provided. The authoring tools are equipped with various functions: 1) drawing and display of objects specified for the respective display mode, 2) management of objects displayed in the current display mode or objects for the display mode specified by the user based on the information input from the application, 3) arbitrary shifting of the point of view of the 360° wraparound view objects on the display screen by changing the point of view parameters, transition of the display mode managed by ID, and 4) calculation of the difference between the values for camera position and angle initially set in the library and the actual values for calibration based on the result.

4. Actual scenes of use

The 360° wraparound view system can be used in various driving situations by synthesizing images from four general-purpose on-board cameras mounted on the front, rear, right and left sides of a vehicle. When parking, the area that becomes a blind spot for the driver can be covered by displaying a 360° wraparound view image together with a single-camera image, which helps the driver to park smoothly and safely [**Figure 4 (a)**]. When driving, a wide-view image of the surroundings of the vehicle can be provided, which offers information about the surroundings of the vehicle that allows the driver to intuitively gain a space perception [**Figure 4 (b)**]. An image from a point of



(a) Example of view when parking



(b) Example of view when driving

Figure 4
Images of 360° wraparound view.

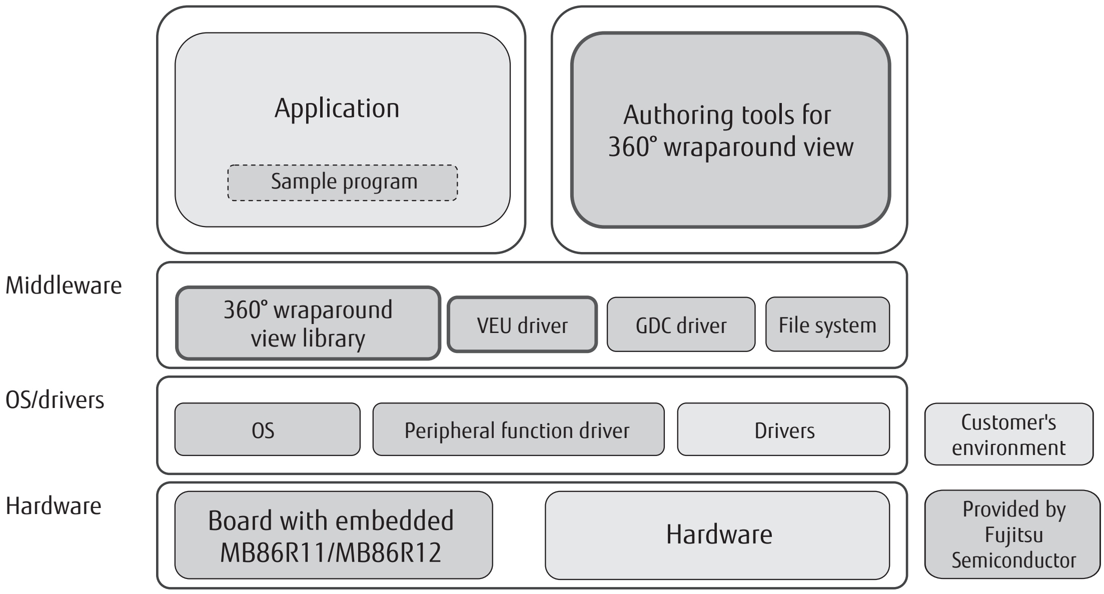


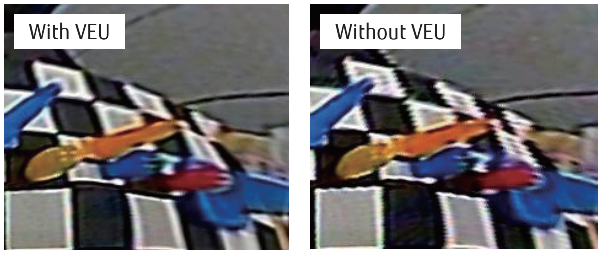
Figure 3
Software configuration for 360° wraparound view.

view in front can be reversed right and left to provide an image like a rearview mirror image, which is useful when changing lanes.

5. Approaches to improvement of image quality

1) Image correction by visibility enhancement function

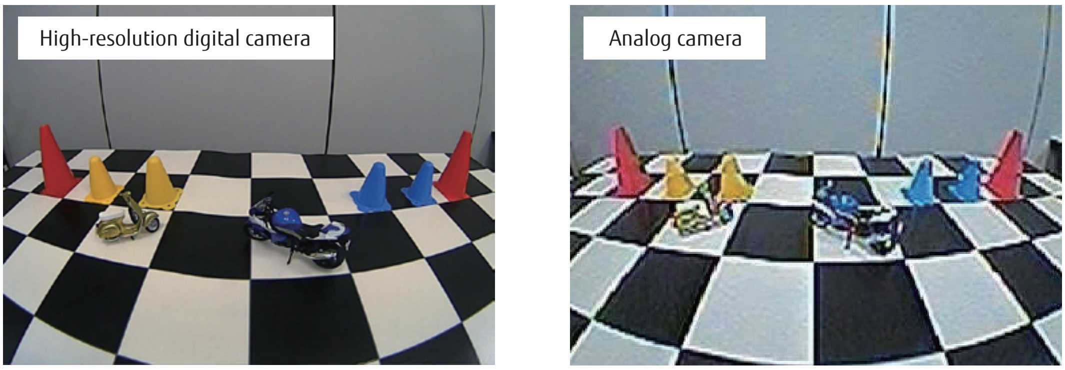
MB86R11 and MB86R12 are equipped with the VEU feature. The VEU has functions for enhancing visibility including IP conversion, scaling, edge enhancement and color processing functions and camera input images can be subjected to correction processing according to each function. These functions reduce flickering due to noise, which is peculiar to analog camera images, and jaggies that are prominent in enlarged areas [**Figure 5 (a)**] and in real time it improves camera images with the visibility deteriorated because



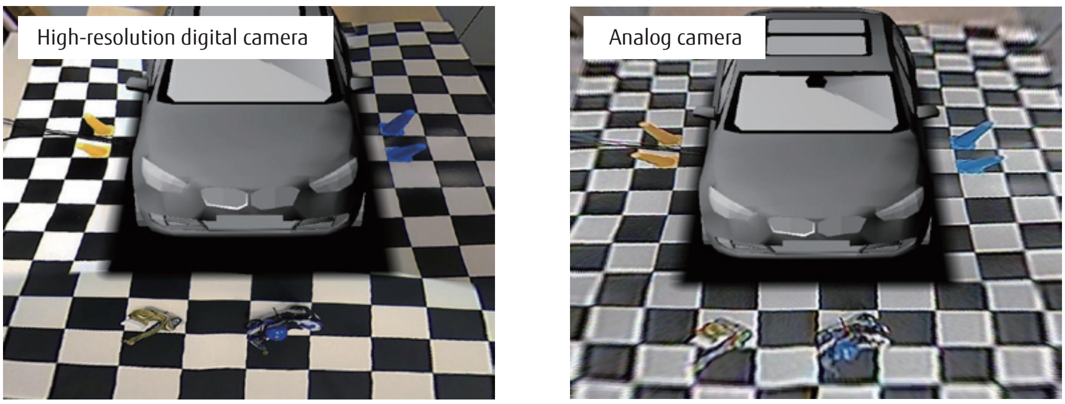
(a) Reduction of jaggies

(b) Improvement of visibility

Figure 5
Effects of VEU.



(a) Single-camera image



(b) 360° wraparound view image

Figure 6
Comparison of image quality of analog camera and high-definition digital camera.

of uneven lighting conditions such as those taken at night or with backlight [**Figure 5 (b)**].

2) Image quality improvement by megapixel camera

In the field of on-board cameras, common analog-output 300 000-pixel cameras are currently used. However, the dissemination of high-definition monitors and the need for combination with image recognition function are expected to accelerate use of megapixel cameras of a 1.2 million-pixel class. Capturing images from 1280 × 800-pixel cameras to the four YUV inputs of MB86R11/MB86R12 will allow 360° wraparound view images, which feature higher quality than those of the existing analog cameras, to be offered to drivers (**Figure 6**).

6. Conclusion

The 360° wraparound view system is realized by combining an in-vehicle graphics SoC (MB86R11/MB86R12), middleware for creating and editing 360° wraparound view images and authoring tools. The technology used for this system has been already commercialized as an imaging solution based on in-vehicle graphics SoC and image processing software and as an on-board camera vision assistance system. In the future, we plan to work on their use in trucks, buses and construction vehicles in addition to passenger vehicles and application to surveillance camera systems. In addition, we intend to link images of the 360° wraparound view system that allow the driver to change the point of view according to various driving situations with a human machine interface (HMI) system based on image recognition technology to provide advanced driver assistance functions.

References

1) S. Shimizu et al.: Wraparound View System for Motor Vehicles. *Fujitsu Sci. Tech. J.*, Vol. 46, No. 1, pp. 95–102 (2010).
2) Y. Toyoda et al.: Visibility Enhancement Technology for In-Vehicle Cameras. (in Japanese), *FUJITSU*, Vol. 59, No. 4, pp. 403–409 (2008).
3) Fujitsu Semiconductor: Graphic Solution to Visually Support the Drivers' Safety OMNIVIEW System. *FIND*, Vol. 29, No. 3, pp. 1–3 (2011).

Suehiro Kawanishi
Fujitsu Semiconductor Ltd.
Mr. Kawanishi is currently engaged in technical support for in-vehicle graphics SoCs.