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Special Reports

Image Processing Technologies for Ultra-High Definition Television (UHDTV)

Future Visual World Actualized by UHDTV Technologies
ISHIBASHI Yasuhiro

Trends in UHDTV Technologies and Toshiba's Approach
MIYAZAKI Toru
Since the introduction of digital high definition television (HDTV: 1,920 x 1,080 pixels) broadcasting services in Japan in 2000, image resolution has become increasingly sophisticated compared with the previous analog-broadcasting television (equivalent to 640 x 480 pixels). With the wide dissemination of HDTV broadcasting, HDTV technologies have been applied to many devices handling video contents in addition to TVs. In recent years, ultra-high definition television (UHDTV), which has a resolution of 3,840 x 2,160 pixels or 7,680 x 4,320 pixels, has been attracting attention for next-generation motion picture services with high picture quality.
Toshiba applied UHDTV technologies to liquid crystal displays (LCDs) for the world's first glasses-free three-dimensional (3D) TVs in December 2010. We are making continuous efforts to commercialize cutting-edge products that can display images with high picture quality and a more realistic sensation by positioning UHDTV as a key technology for image entertainment devices.

Latest High Picture Quality Technologies for UHDTV
NAKAMURA Masaki / YAMADA Kazuhiro / MIYAZAWA Hirotoshi
Demand has been increasing for ultra-high definition television (UHDTV), which features a UHD liquid crystal display (LCD) with 3,840 x 2,160 pixels, accompanying the upsizing of screen sizes in recent years. In line with this trend, there is an increasing need for high picture quality technologies to project clearer images on the screen.
Toshiba launched the REGZA 55X3, the world's first UHDTV for consumer use, in 2011. We have now developed and commercialized the REGZA Z9X series flagship models of the REGZA lineup, which incorporate the following latest UHDTV technologies to achieve high picture quality: a high-brightness and wide color gamut LCD applied to the 50/58/65Z9X models, a proprietary picture quality algorithm for the reproduction of clearer and more colorful images, and a super-resolution technology for the noise generation area of digital broadcasting contents.

UHDTV Interface Technologies
TOMODA Ichiro / DOI Takashi / MATSUMURA Masafumi
To meet the growing demand for audio and video data transfer between digital audiovisual devices, there is an increasing need for high-speed interface technologies that comply with standards including HDMI (High-Definition Multimedia Interface), MHL (Mobile High-Definition Link), and DisplayPort. In recent years, such standards have been required to handle high data transfer speeds for ultra-high definition television (UHDTV). In response to these circumstances, version 3.0 of the MHL specification was released in August 2013 and version 2.0 of the HDMI specification was released in September 2013.
Toshiba has been continuously engaged in efforts not only to promote the standardization of UHDTV interface technologies as a founding member of these standards organizations, but also the research and development of products applying these standards.

Approaches toward Realization of UHDTV Broadcasting
HIROTA Atsushi
Accompanying the ongoing dissemination of large-screen TV receivers, the movement toward the introduction of ultra-high definition television (UHDTV) broadcasts with enhanced picture quality has accelerated both in Japan and other countries. As part of Japan's growth strategy utilizing information and communication technology (ICT), the development of UHDTV broadcasting technologies is progressing to realize a world-leading next-generation broadcasting service through the cooperation of the public and private sectors including major broadcasters and manufacturers. Active efforts are being made for the standardization of UHDTV satellite broadcasting technologies, as well as the development of a roadmap from the commencement of 4K broadcasts in 2014 with a broadcast resolution of 3,840 x 2,160 pixels using communication satellites (CSs) at an east longitude of 124/128 degrees, through to 8K experimental broadcasts in 2016 and the start of 8K broadcasts in 2020 with a broadcast resolution of 7,680 x 4,320 pixels using a broadcasting satellite (BS) and CSs at an east longitude of 110 degrees.
Toshiba has been actively participating in study groups and standardization activities for UHDTV broadcasting technologies from the initial stage of development in order to provide viewers with more realistic and higher quality images.

H.265/HEVC Video Coding Standard Contributing to Realization of UHDTV Broadcasting
KAWASHIMA Yuji
The H.265/HEVC (High Efficiency Video Coding) standard, which was jointly standardized by the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) and the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) in January 2013, has been adopted as one of the video coding standards for ultra-high definition television (UHDTV) digital satellite broadcasting. H.265/HEVC achieves approximately double the coding efficiency of the H.264/AVC (Advanced Video Coding) standard for current HDTV broadcasting.
With the aim of realizing innovative broadcasting and network services delivering outstanding picture quality, Toshiba has been devoting continuous efforts to the promotion of standardization in this field as a member of related working groups and has been contributing to the improvement of coding efficiency.

LSI Design Technologies for UHDTV Video Processing
KATO Yoshiyuki / MAKI Yasunori
With the introduction in recent years of ultra-high definition television (UHDTV), which has a resolution of 3,840 x 2,160 pixels, four times that of full high-definition (HD) TV, the increase in circuit scale and memory bandwidth (i.e., data transfer rate) required for signal processing has become a serious issue. In addition, there is an ongoing need for higher memory bandwidth to meet the requirements for graphical processing with higher quality. Although the increase in circuit scale can be achieved through the progress made in miniaturization of large-scale integrations (LSIs), the securing of increased memory bandwidth has remained a critical issue.
Toshiba has developed LSI design technologies in order to realize high-quality UHDTV video processing. These include an optimization design to provide distributed processing in which decode processing and image-quality enhancement processing are conducted separately instead of concentrating the processes in only one LSI chip, and technologies for a new video processing engine called the " REGZA ENGINE CEVO 4K" to make effective use of memory bandwidth by applying bandwidth compression, a memory scheduler, and a stacked dynamic random access memory (DRAM).

Application of UHDTV Technology to Glasses-Free 3D Display Systems Requiring High Resolution
TAKIMOTO Takahiro
Toshiba commercialized the world's first glasses-free three-dimensional (3D) TVs that do not require dedicated glasses, the REGZA GL1 series, in December 2010, and subsequently introduced the REGZA 55X3 glasses-free 3D TV equipped with a large high-definition display appropriate for living rooms in December 2011. We developed these REGZA series glasses-free 3D TVs by making use of ultra-high definition television (UHDTV) technology as well as our proprietary technologies including an integral imaging (II) system, a multiparallax conversion algorithm, and a viewing position optimization method applying face tracking technology. Furthermore, we are developing business-to-business (B2B) applications such as a glasses-free 3D medical display system based on technologies acquired through the development of REGZA series glasses-free 3D TVs.

Feature Articles

Small Compound-Eye Camera Module Providing Depth Map and 2 Mpixel 2D Color Image in One Shot
UENO Risako / SUZUKI Kazuhiro / FUNAKI Hideyuki
Depth cameras, which can calculate the camera-to-object distance as well as the object image, have recently become available as an input interface for game machines. Such cameras have been conventionally based on an active method using a reference light source in order to measure the distance between the camera and objects, resulting in increased power consumption and size due to the addition of light components including a light source and dedicated sensor to a normal visual type camera. The usage environment is also limited because this method is significantly affected by outdoor light.
To overcome these problems, Toshiba has developed a small compound-eye camera module with dimensions of 8.5 x 8.5 x 6.0 mm appropriate for mobile devices, consisting of a single lens unit, a microlens array (MLA) attached to an 8 Mpixel color complementary metal-oxide semiconductor (CMOS) sensor, and a read-out board, based on a light-field technology. This camera module makes it possible to provide a depth image with 26,000 data points and a refocused 2 Mpixel two-dimensional (2D) color image by means of a captured raw image in one shot and one frame.

Organic Photovoltaics Offering Various Power Supply Applications
TODORI Kenji / HOSOYA Masahiro / SAITO Mitsunaga
Organic photovoltaics (OPV), a technology that has several advantages including light weight, flexibility, and low cost due to its use of thin-film fabrication employing a printing process, is now attracting attention as an alternative to silicon (Si) solar cells with the potential for application to various situations.
Toshiba has been developing OPV for not only solar panels but other applications as well, including devices used under indoor light and with curved structures. We have developed a prototype OPV cell and submodule, and confirmed that the conversion efficiency under sunlight of an OPV cell with dimensions of 1 x 1 cm is 10.3% and that of a 5 x 5 cm OPV minimodule is 9.1%. The conversion efficiency of the OPV cell under indoor light is higher than that under sunlight because of its higher sensitivity in the visible range compared with Si solar cells. The newly developed OPV cell, minimodule, and submodule are therefore expected to be applied to power supplies for indoor electronic devices such as electronic shelf labels, sensors, and similar devices.

Test Case Selection Method Using Mathematical Programming Model
SASAKI Manami / OGASAWARA Hideto / TSUKUI Hideki
Software testing performed in the final stage of development of software systems is essential to ensure software quality. While the number of test cases for verification and validation has sharply increased with the dissemination of larger scale and more complex software systems in recent years, software development periods have been becoming shorter year by year. Under these circumstances, there is a need for highly sophisticated and rapid testing that can detect defects earlier, more effectively, and with greater certainty.
As a solution to this issue, Toshiba, in cooperation with Ehime University, has developed a test case selection method that offers a set of the most effective test cases by calculating the highest expected values of failure detection based on a 0-1 programming model from among large numbers of test cases within an environment of constrained resources. We have confirmed the effectiveness of this method by applying it to the development of medical equipment.

Automatic Testing Technologies for I&C Systems for Nuclear Power Plants
YOSHIDA Motoko / SUGIO Takayuki / KONISHI Tadao
With the aim of enhancing the global competitiveness of instrumentation and control (I&C) systems for nuclear power plants, Toshiba has been making efforts to reduce the worker hours required for the testing of such systems and improve the quality of the tests. Display screen tests, which include many routine, repetitive tests and manual tests requiring a large number of operators to monitor multiple screen displays of the I&C system, are an essential element of the testing process. The introduction of automatic testing technologies is expected to substantially improve the efficiency of such display screen tests. We have now developed automatic testing technologies for display screen tests that can be applied without the need to change the I&C system. These technologies contribute to both the reduction of worker hours for testing and improvement of the quality of the tests.

Inter-Station Logic Controller for Keiyo Line of East Japan Railway Company
OKADA Tetsuya / NISHIKI Akio
In conventional railway signaling systems, inter-station signaling devices that are distributed along the railway line are connected to control devices through a large number of copper wires. The increasing number of such wires has been making it extremely complicated for railway workers to construct, inspect, and manage these devices.
As a solution to this issue, East Japan Railway Company has been developing a new inter-station network signal control system to enhance workability, maintainability, and reliability by reducing the use of wires and integrating devices and functions by means of information and communication technology (ICT). Toshiba has developed an inter-station logic controller (LC) as a device that conducts integral processing of inter-station signal control logics, and delivered the first inter-station LC to Shin-Narashino Station on the Keiyo Line. Commercial operation of this LC started in July 2013, and it is contributing to the safe and stable operation of overcrowded railway lines in the Tokyo metropolitan area.

Technology to Control Volume Balance between Voices and Background Sounds for TV Products Based on Sound Source Separation Technology
AMADA Tadashi / TAKEUCHI Hirokazu
The progress made in the field of digital TVs in recent years has led to advances in complex digital signal processing technologies for audio signals. One such technology is sound compensation technology to provide sound quality matching the preferences of viewers and the scenes of TV programs.
Toshiba has developed a new sound source separation technology that allows viewers to watch a variety of TV programs with their preferred volume balance, which is achieved by separating human voices and background sounds and independently adjusting the volume balance for each. We have also launched TV products equipped with this new technology.

4K UHD Monitor Achieving 99% Coverage of Adobe® RGB Color Space
SAKAMOTO Tsutomu / YAMANAKA Satoru / NAKAMURA Atsushi
For professional image editors creating computer graphics and processing photographs, videos, and so on, liquid crystal display (LCD) monitors capable of accurate color reproduction and high screen uniformity without luminance and color non-uniformity are essential. Furthermore, demand has risen for LCD monitors with higher resolution accompanying the increase in the pixel count of digital cameras and the dissemination of video contents with 4K (3,840 x 2,160 pixels) ultra-high definition (UHD) resolution in recent years.
In response to these sophisticated requirements, Toshiba Lifestyle Products & Services Corporation has developed the TUM-32PRO1 4K UHD LCD monitor equipped with a 32-inch display. This monitor achieves 99% coverage of the Adobe® RGB color space, high screen uniformity, faithful color reproduction, and high contrast even in bright environments.

Frontiers of Research & Development

SeeQVault Next-Generation Content Protection Technology Allowing High-Definition Contents to Be Carried Safely and Easily