

NEC's Pursuit of Imaging and Recognition Technologies

Keeping pace with recent advances in information and communication technologies and device technologies, video and other images have become a more integral part of our lives, while the scope of the application of imaging technologies has continued to broaden.

Over its long history, NEC has pioneered development in imaging technologies and contributed to achievements in many fields from broadcasting video to image recognition. Applying these highly sophisticated imaging technologies, NEC is providing solutions that are answering and anticipating customer needs.

This special issue will provide a general explanation of NEC's pursuit of imaging and recognition technologies by giving the reader a historical review and an outline of NEC's achievements in the fields of "Imaging capture and transmission technology," and "Imaging analysis and processing technology." With a focus on the three areas of "Image recognition/analysis," "Image accumulation/processing," and "Image distribution," this article will introduce various imaging solutions that incorporate the application of these technologies and create new value for users.

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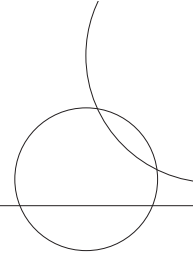
1 Introduction

In step with recent advances in information, communications and device technologies, the scope of the application of imaging technologies has continued to expand significantly. While current utilization of imaging technologies has been centered on their simple application for the capture, recording and playback of images for entertainment purposes, advances in microprocessor and memory technologies, increases in camera performance, and the transition to broadband telecommunications and the falling cost of usage have not only made possible imaging solutions in various industrial and business application areas such as surveillance and management, but also benefited general users with a growing diversity of image utilization including recording and sharing images in a variety of everyday scenes. Video distribution/streaming systems for network carriers and other NEC imaging and recognition technologies have also evolved in recent years as demonstrated by the exam-

ple of camera-equipped vending machines that can recognize the age and gender of the user and "recommend" the optimum product to the user. This article hopes to provide the reader with a simple introduction to NEC's pursuit and approach to the development of imaging and recognition technologies.

2 History of NEC's Imaging and Recognition Technologies

Human beings as well as many living things act on the information gathered by the sense of vision, and its importance requires no description here. It can be said that imaging and recognition technologies expand the visual sense through the power of machines and devices. The history of imaging and recognition technologies is a journey that begins with the development of vision that transcends time (image recording and playback) and vision that transcends distance (image transmission from remote locations), and continues to evolve with vision that reveals the invisible and even device-based alterna-



tives for the vision function itself (image recognition/understanding).

The history of NEC's imaging and recognition technologies traces this path of development. In 1928, Yasujiro Niwa and Masatsugu Kobayashi completed development of their NE-type phototelegraphic device - Japan's first facsimile, and succeeded in the experimental wired transmission of an image between Tokyo and Osaka (**Photo**). At that time when all major domestic newspaper publishers were using imported phototelegraphic equipment and getting poor results, the NE-type device demonstrated the superiority of its approach to the world when it transmitted high-quality photos of the Showa Emperor's enthronement ceremony with outstanding speed. This same approach is the foundation of modern FAX technology used today.

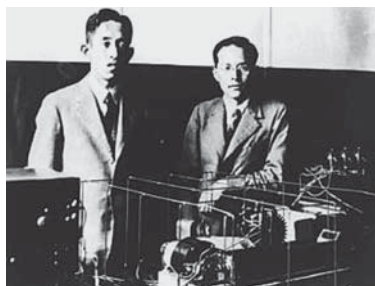


Photo Developers of the NE-type phototelegraphic device, Yasujiro Niwa (left) and Masatsugu Kobayashi (right).

Since then, NEC has undertaken the development of image/video transmission and encoding technologies for telecommunication carriers and broadcasting companies, and has made large contributions to these industries both in Japan and overseas. As a result of NEC's aggressive proposal of protocols for international standards, which are essential to telecommunication devices, numerous NEC technologies including MPEG and many other important standards have been adopted.

Also the advent of the computers and subsequent advances led to the development of image analysis and recognition technologies. In the 1960s, NEC began tackling the development of character recognition and fingerprint matching technologies. Today those technologies continue to evolve with improvements in performance and accuracy. Honed by a half-century of development, machine learning and various image processing technologies comprise the foundation of face recognition and object identification technologies that represent a higher order of technical difficulty. Moreover, they are the source of NEC's continuing development of world-class high-performance imaging and recognition technologies.

3 Categorization of Imaging and Recognition Technologies

There are numerous categories of elementary imaging and recognition technologies, but from the perspective of solutions, they can be broadly classified according to "Function

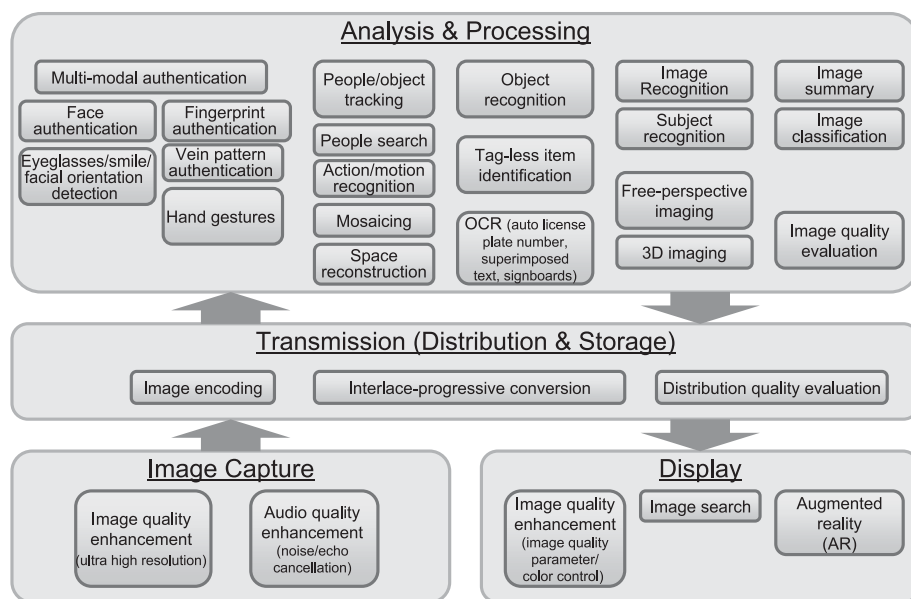


Fig. 1 Imaging technology classification by "function."

(processing objective and application)” and “Subject (video content, photographic subject, etc.)

“Function” categories are organized by the flow of image processing (Fig. 1).

- 1) Technologies that enable the capture and fundamental processing of images (sensing, image quality enhancement, multi-view image capture, 3D image capture)
- 2) Technologies that enable the transmission and recording of images for anywhere, anytime utilization (high-efficiency encoding, video distribution/streaming)
- 3) Technologies that enable image analysis and processing for machine understanding and processing of image data (photo subject detection/recognition, image search, computer-generated imaging)
- 4) Technologies that enable the rendering images in a format that the human eye can recognize (device rendering, 3D conversion)

Categorization by “Subject” focuses on the content of the image.

- 1) Technologies that manipulates the overall characteristics of the image as a series of signals and coding (high-efficiency encoding, image discrimination)
- 2) Technologies that can determine class-separable features within an image and perform processing specific to image subject types (people, objects, animals, characters, etc.) (OCR, face recognition, object recognition)

Actual systems and services are realized through the combination of diverse technologies, and NEC is at the forefront of the development of a variety of these cutting-edge component technologies.

4 NEC's Leading Technologies

NEC is moving forward in the research and development of cutting-edge technologies with a focus on 1) high-quality image capture technology and narrow-band transmission technology with the aim of greatly expanding the scope of image utilization, and 2) analysis and processing technologies that empower IT with remarkable processing capabilities.

4.1 Image Capture & Transmission Technologies

In the field of image capture and transmission technology, NEC is pursuing development with a focus on image signal processing. This technology aims at processing image data captured in diverse shooting environments and delivering the data in the optimum condition for utilization in a variety of applications.

Serving as the foundation of every imaginable imaging solu-

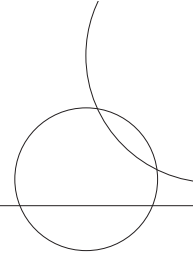
tion, image capture technology uses low-cost image capture devices to generate imaging data that must satisfy the required conditions of each application. NEC has established PictMagic, a comprehensive family of technologies for image quality enhancement or optimization for various applications, and is pursuing broad development from high-end industrial-use image quality enhancement solutions for the publishing industry to image quality processing for images captured with mobile phones for consumers. PictMagic not only performs quality enhancement, but also is characterized by its capability to recognize various types of shooting scenes and then perform real-time enhancement on computational-resource-restricted device and to optimize results for the unique subject characteristics of people (portraits), flowers, landscapes, etc., making possible reproduction of natural textural quality by scene analysis.

In transmission technology, which could be called one of the core technologies of NEC, the company has advanced development in this field with a focus on high-end video encoding technologies that enable high-quality video recording and transmission, keeping pace with the broadcast industry's transition to digital technology. NEC has commercialized products that establish low-delay, high-efficiency encoding methods necessary to secure the interactivity demanded by shift to full-digital systems in broadcasting studios in recent years. Also in response to the rapid expansion of mobile data communications, NEC engineers are moving forward with the establishment of technologies that pave the way for the international standardization of the next-generation encoding (High Efficiency Video Coding:HEVC) that achieve twice the compression efficiency of the latest standard as well as end-to-end quality management.

4.2 Analysis & Processing Technologies

In the domain of analysis and processing technologies, NEC is moving forward with the development of various technologies to respond to customer needs, but is especially pouring its efforts into (1) “people recognition” technologies such as facial recognition, and (2) “content management” (image/video search) technologies.

Face recognition technology is not only vital to ensuring public safety and security through its application in border control management, national ID document management, airport surveillance and facility surveillance, but also is finding broad application in everyday private life where it can facilitate tasks such as photo search or make user interfaces easier to use. Since the launch of the face detection/matching engine “NeoFace” in 2002, NEC has taken this technology into variety business areas both in Japan and abroad. In 2010, NEC developed the world's highest performance face recognition technology - superior in



every aspect from recognition accuracy and search accuracy to processing speed. In Multiple Biometric Evaluation (MBE) Still-Face Track benchmark testing conducted by the National Institute of Standards and Technology (NIST), NEC boasted the highest accuracy with a 92% identification rate from a 1.6 million-person database (2nd place: 87%), the lowest False Reject Rate of 0.3% (1/10 the value of the 2nd ranked system) at a False Accept Rate of 0.1%, and the fastest average time of 0.39 seconds (1/7 the time of the 2nd ranked vendor) to process a query from a total of 1.6 million images. In every test category, the NEC system proved clearly superior in performance and secured the number one ranking. (Fig. 2). This technology has already been made commercially available in the latest versions of NeoFace.

Besides the face recognition technology, NEC is also developing technologies that can determine gender and age (Field Analyst), track patterns of human movement and search for individuals based on apparel and other characteristics recorded in an image, and applying them in digital signage and video surveillance solutions. In these technological developments, NEC's layered utilization of its original generalized learning vector quantization (GLVQ) technology - the product of long years of refinement as a core technology, its image processing technologies and other innovations form the basis for the clear technological difference from other vendors.

In the area of content management, NEC is developing and commercializing image archive search technology for both large-scale users such as telecommunications carriers and

general consumers for use in managing personal collections. One of the recent fruits of NEC's work in this field is video/image identification technology which is the basis of automatic detection of pirated or illegal distributed content & an issue that is growing increasingly serious in step with the expanded distribution of video via the Internet.

5 Solutions Exploiting Imaging and Recognition Technologies

Even a single imaging technology can result in a broad diversity of applications. Always seeking to extract multiple values from a single technology and combining technologies to create new value wherever possible, NEC continues to give birth to many innovative solutions that exploit our imaging and recognition technologies and play a role in a variety of scenes in work and daily life.

Fig. 3 shows various examples of solutions made possible by the processing of images from surveillance cameras. In these examples, the reader can see technologies that recognize, track and analyze movement of people and other subjects from images. By analyzing the movement of people in the workplace, this application can contribute to improving work efficiency and ease movement in the workplace. By analyzing and detecting the line of movement of a person passing through a place where people normally gather, we can identify persons moving suspiciously, which in turn, leads to the prevention of crime. The analysis of the movement patterns of shoppers in a shop can contribute to more effective placement of product displays. Automatic alerts when a person enters a hazardous area or detection of unauthorized entry are also made possible by these technologies. And if facial recognition technologies are used with images captured by surveillance cameras, it is possible to find a specific person in a crowd of people, authenticate persons occupying a room or identify a highly valued client.

Also by using event/incident recognition based on images captured by roadside surveillance cameras, accidents and disabled vehicles can be detected and appropriate response automatically dispatched, preventing secondary collisions and accidents. In this way, the imaging and recognition technologies of NEC can contribute to improved traffic safety and accelerate the clearing of accident sites, ambulance dispatch and other emergency response.

NEC's fingerprint matching technology and face recognition technology are both globally ranked among the best in the world. By applying these technologies in combination, individual fruits can be recognized from their exterior appearance. For example, it is possible to recognize a particular melon from others by its distinctive surface pattern. With this technology,

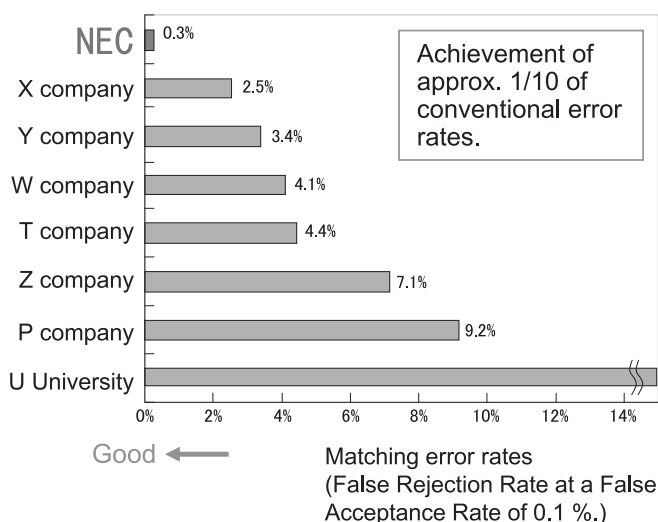


Fig. 2 Superior Performance of NEC Face Recognition Technology (National Institute of Standards and Technology (NIST), USA benchmark results).

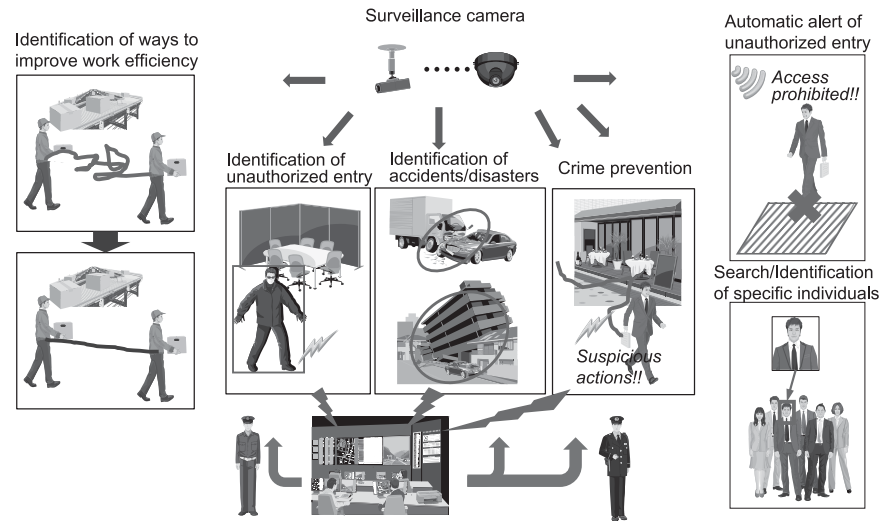


Fig. 3 Video surveillance.

cultivation records, the area of its origin and other information about each melon can be retrieved without using bar code labels or electronic tags.

Fig. 4 provides an overall view of imaging and recognition technologies and the solutions that apply those technologies.

From a core technology, a level of technology that can apply it as a solution is conceived. Solutions with this application technology as a base are created. Then a single solution can be adapted to respond to the specific needs of a type of industry or business.

In this special issue, solutions will be grouped and introduced according to the following 3 categories in order to facilitate ease of understanding:

- Image recognition/analysis (processing of the image itself and applications)
- Image accumulation/processing (methods of handling image data)
- Image distribution (communication using images).

The following provides an overview of each category.

5.1 Image Recognition/Analysis (Processing of the image itself and applications)

Image recognition and analysis technologies detect and recognize who or what has been captured in an image of a person, object or landscape. At the same time, these technologies analyze the conditions of these captured subjects and also the changes that occur over time. It is the technology that clarifies significant information from these factors. This section will introduce several solutions applied these technologies.

As previously introduced, “Flow Line Analysis Technology for ‘Visualizing’ Human Behavior and Utilization Examples” has a variety of applications.

“Interactive Image Control System employing Face Recognition Technology” enable the interactive control and display of images and video by using face matching rates. *(This paper is not included in this journal.)*

“Video Identification Solution Using a ‘Video Signature’” use can make the registration of new video content more efficient and make the relationship between an original and edited copy more visible by using a technology called video signatures which generate a video “fingerprint” based on quantitative values unique to the video content and then using them to find copies.

5.2 Image Accumulation/Processing (Methods of handling image data)

In the case of terrestrial digital television broadcasting, digital cinema and 3D images/video, one title can require from dozens to hundreds of gigabytes of data.

Technologies for the high-reliability, high-efficiency storage, search/retrieval, processing, transmission and reception of this vast amount of image data are urgently needed. Here we would like to introduce solutions that apply NEC’s image/video storage and processing-related technologies.

“Implementation Method of the Large-Capacity Data Distribution and Hybrid Cloud System” is one of the core technologies in this solution category. *(This paper is not included in this journal.)* “Evolution of File-Based Image Archiving System”

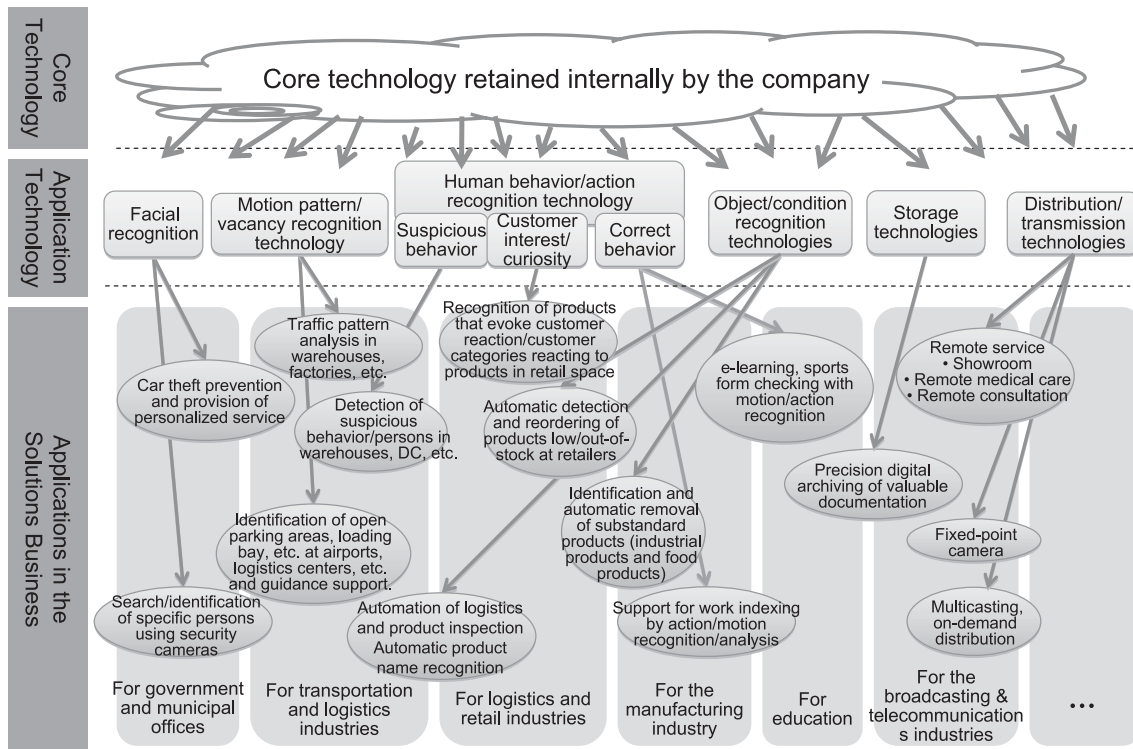


Fig. 4 Imaging technology application solutions.

not only provides management of video/image content, but also provides a new content distribution business flow. “Broadcasting Service Platform Solution of the Next Generation” provides a next-generation service platform to support the new services that will be tackled by broadcasting stations after analog broadcasts are terminated. “Total Nonlinear Editing Solution that Supports News Production Scenarios” provides users with solutions that support accurate and speedy reporting of the news by improving workflow of news departments at broadcasting stations and utilizing metadata. “Rich Graphics Solution for Embedded Device - GA88 Series IWAYAG -” optimizes the graphics required for “rich user interfaces” with vector graphics technology. “Development of Ultra-low Latency Codec” enables the provision of broadcasting solutions that deliver improved “real time” performance by realizing a codec delay as little as 10ms while preserving broadcast image quality.

5.3 Image Distribution (Communication using images)

The use of digital video as a means of communication will give birth to a variety of value-added communication.

Remote tourist guides and language interpretation services using “Wearable Unified Communication for Remote Tour

Guide and Interpretation Services” will enable the provision of tour guide and interpreter services for foreign tourists in their native language. “Trends in Digital Signage Solutions” will dynamically provide advertising with consideration for viewer’s attributes and condition. The communication robot “PaPeRo” is already pointing the way to exciting possibilities for the next generation of communication.

6 Future Prospects for Imaging and Recognition Technologies

Against the background of cameras and recording media increasing in functionality while falling in cost, and the continued shift of telecommunications to broadband, further expansion and acceleration of solutions that use images and video are foreseen. However, even at this current point in time, applications that support actual human visual perception and judgment of the image content itself remain the mainstream, while automatic control/management as well as meaning-oriented processing (search using text, etc.) can be realized only under limited conditions. In the future, through further advances in image/video recognition/analysis and processing technologies,

we will aim at converting image/video content into a format that can be more easily used by devices and realize solutions that can use it in broader applications. Also regarding the current state of imaging and recognition solution, the cost required for the system customization when the system is installed is quite high in many instances to achieve the practical performance of products. This results in a cost reduction bottleneck that must be addressed. NEC is energetically tackling this problem, and is developing technology that optimizes solutions for each installation environment in a shorter time while ensuring they remain robust solutions once in operation. With the aim of realizing the utilization of imaging and recognition technologies in a broader range of scenes as early as possible, NEC is moving forward with the development of innovative technologies and products.

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Remarks for Special Issue on Imaging and Recognition Solutions

NEC's Pursuit of Imaging and Recognition Technologies

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Image recognition/analysis

Flow Line Analysis Technology for "Visualizing" Human Behavior and Utilization Examples

Video Identification Solution Using a "Video Signature"

Image accumulation/processing

Evolution of File-Based Image Archiving System

Broadcasting Service Platform Solution of the Next Generation

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Wearable Unified Communication for Remote Tour Guide and Interpretation Services

Trends in Digital Signage Solutions

Next Generation Communication with a "Telecommunication Robot"

◇ General Papers

Development of a High-Intensity Projector Using LED Light Source

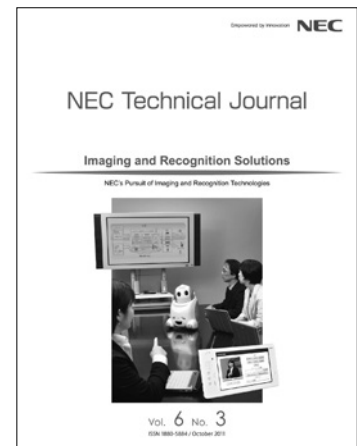
Development of an Environmentally Conscious LCD Projector

Improved Projector Functions Based on System Linkage with PC

The MultiSync PA Series of Professional Display Offers Both Accurate Color Reproduction and High Usability

Development of a Video Wall Display System Using Ultrathin-Bezel LCD Panels

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