Optacon method to transmit video images. In the 1990s, there was research into a three-dimensional tactile display that could display images by multi-value raising and lowering of static stimulators similar to those of TVSS through heights of up to about 10 mm. However, these devices had problems of cost and, since there wasn't yet any great need for information media at that time, they failed to become practical products.

(2) Touch presentation devices and research and development trends for information barrier-free systems

Touch presentation devices that have been developed with the objection of creating information barrier-free systems are classified by their representative functions, with the characteristics, interactive capabilities, purposes, and costs of these methods being listed in Table 2.

At the beginning of the 2000s, a mouse-type tactile display, in which stimulus pins driven by piezoelectric reeds were mounted on the operational surface of the mouse, and a wide-area two-dimensional tactile display became practicable and were commercialized. At the moment, there is research and development into two-dimensional tactile displays, aimed at improving interactivity and higher resolutions and reducing costs. Concerning interactivity, it is possible to detect the positions of hands or fingers that are touching objects, by a method of using acceleration sensors to detect the contact positions of fingers and the optical touch panel method developed by NHK. In other words, a tactile display can be used to enable the provision of interactive information such as that needed for navigating a GUI or reading a map, which is expected to lead to dramatic advances in the informational environment for visually-impaired people. Concerning the challenges of producing higher resolutions and lower costs, a drive method that is being developed uses a mechanical scanning mechanism to raise and lower stimulus pins, without having to provide any drive mechanism for stimulus pins arranged in a two-dimensional array. There is also research underway into the manufacturing process, in order to integrate the stimulus and drive parts by using micromachine technology and organic semiconductor technology. These technologies can be expected to produce an inexpensive high-definition, wide-screen, two-dimensional touch presentation device in the future.

In the virtual reality field, there is research and development into haptic[13] (touch/force senses) presentation devices which provide a different way of presenting a solid object virtually to the touch/force senses. A haptic presentation device basically has sensors that detect the positions of the hands or fingers. It makes it easy to present not just three-dimensional information, but also two-dimensional information such as that in figures and graphs, and is expected to find applications in information barrier-free systems.

5.2 Effective GUI navigation and research trends

(1) Multimodal presentation of GUI screen

As GUIs became more popular, there was research into support technology for conveying the structures of selection objects such as on-screen icons and hierarchical structures to visually-impaired people through the sense of touch, to help them search for and obtain the information they want (called "touch navigation" in the rest of this article). There are two methods of conveying a GUI screen configuration: a "screen presentation method" that displays the screen layout such as selection objects in a more-or-less faithful manner, and a "logic presentation method" that reorganizes the shapes and placements of the selection objects into a logical layout. A tactile display can be made to correspond to either method. With a two-dimensional tactile display, it is possible to present the entire screen at the same time so the user can explore any part of it by touch. But a mouse-type tactile display has a limited area so it is necessary to build up an image of the entire screen by scanning it with the fingers.

Visually depicted content has increased recently, making it necessary to improve accessibility by using touch. Touch presentation devices are also being pushed into practical use and commercialized. With Web accessibility, research is broadening from audio navigation by sound and operation keys to touch navigation using both audio and a touch presentation device, and the effects of multimodal presentation in different tasks are being reported on.

For example, a system that is being prototyped uses both a mouse-type tactile display and a tablet[14] to freeze a graphic image corresponding to the positions of the hands and fingers on the tablet and present it on the mouse-type tactile display. The results of experiments designed to transmit toolbars and graphs are confirming that combinations with touch make the content easier to comprehend. According to experimental results of evaluating different tasks in a multimodal presentation system combines senses such as sight, hearing, and touch, there are significant improvements in search time and task performance efficiency in comparison with systems using sight alone, and the combined use of touch as well demonstrates superior performance in tasks that are complicated and have a heavy load. Furthermore,

13: Haptic. A sense that combines the sense of touching an object with the sense of force obtained from the joints when a hand or arm is moved.

14: Flat input device for detecting a position on the screen.

cooperation between visually-impaired people, Web creators, and haptic developers has led to evaluation surveys with the goals of determining what sort of touch presentation of elements such as icons and hyperlinks[15] is preferable and how to specify presentation methods, and the creation of guidelines is being investigated.

(2) GUI navigation by vibration stimulus and the presentation of document attributes information

With GUI navigation, it is necessary to have a function that keeps the user informed in an intuitive and also accurate manner about operational responses or the current status during information acquisition. The effects of using multimodal means such as tactile stimuli by vibration or auditory signals to convey details of character attributes (such as character sizes, fonts, and colors that are used extensively on the Web) and document structure (such as title headings and link destinations) are also being evaluated. These functions are essential to deaf-blind people, and would also form an effective transmission means for visually-impaired people who are not deaf-blind.

15: Method of embedding positional information in documents on the Web, to link to other documents or graphics.

5.3 Effective transmission of figures and tables

As described in Section 5.1, touch presentation devices that enable interactive operations and can change the display dynamically in real time can lead us to expect to see new methods of presenting figures, tables, and graphics information. Current research along these lines include research into a method of using a mouse-type tactile display to enable users to feel and identify diagrams within a small area and research relating to methods of presenting visual content by a two-dimensional tactile display. There have been various reports on methods using a two-dimensional tactile display, such as a method in which the Web content is divided into categories such as figures, tables, and text, then enlarges the figures for display and displays text data in Braille to make the content easy to perceive by touch. In another method, a description at the portion of

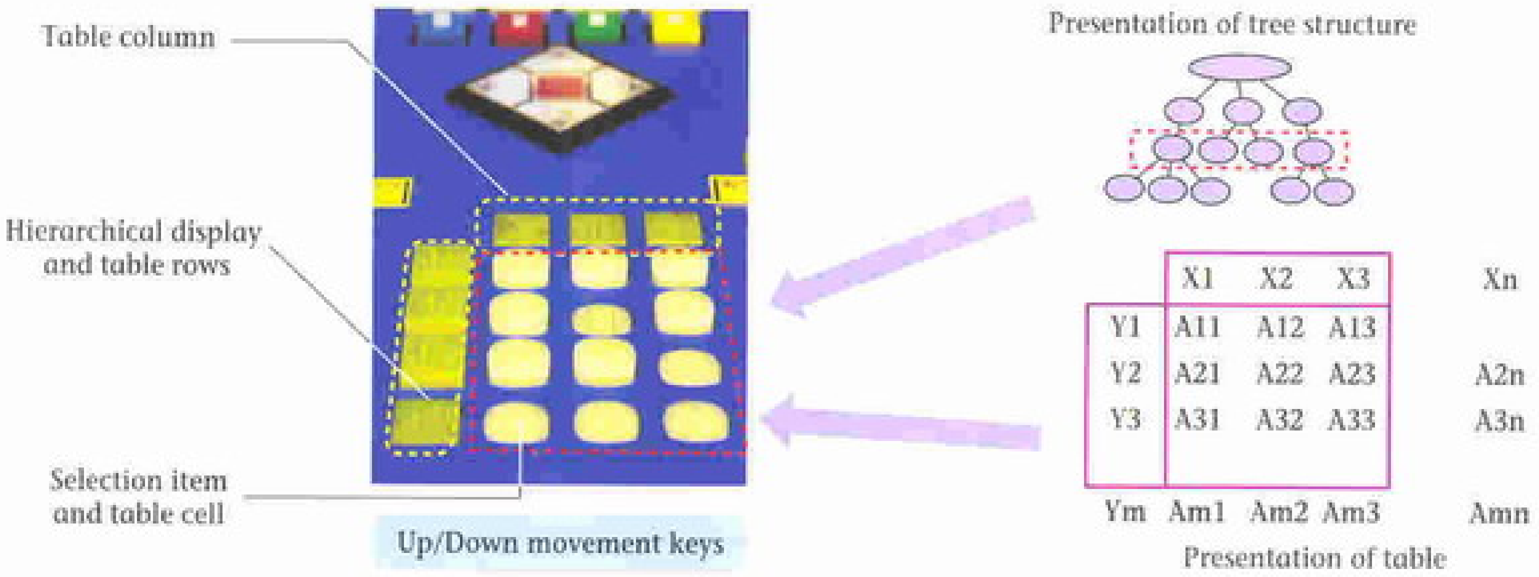


Figure 4: Information presentation by touch navigation

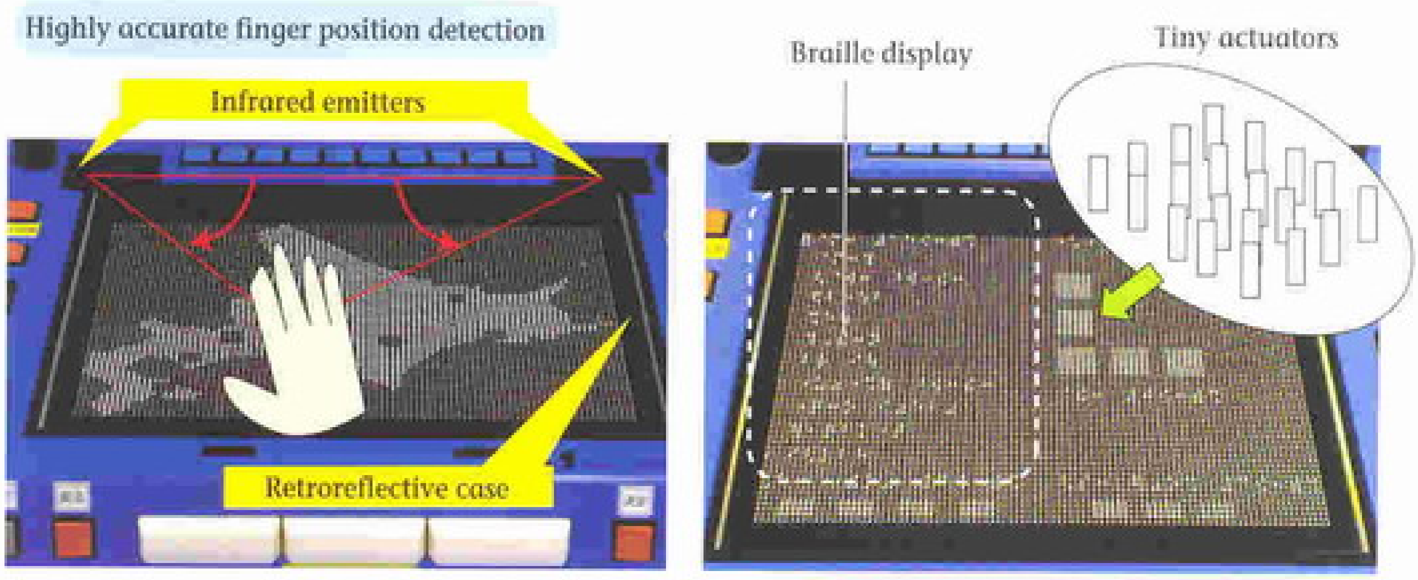


Figure 5: Configuration and Braille presentation of interactive tactile display

a map that the user is currently touching is read out by a text reader.

Basic research is being conducted with the goal of using haptic presentation devices to transmit information such as that on the GUI, figures, graphs, and maps. As the result of comparing a method of using a haptic presentation device and audio together and a method of touching a tactile chart[16] created for visually-impaired people, it was reported that the former method was effective from the viewpoints of comprehending line graphs and bar charts, and mental workload[17]. There have also been reports on the results of evaluation experiments relating to the ability to differentiate between the heights of adjacent bars in a bar chart and the ability to differentiate vibration patterns, to obtain guidelines for presenting graphs.

To present table information, the current method is to use cursor-key operations and audio to move along the rows and columns to verify the contents of the cells. However, trying to grasp the positional relationships within a table by just audio means places a large load on the user. In addition, no effective presentation method has been established for irregular table formats such as those of TV program charts and timetables. It is considered effective to present such tables in a spatial manner by touch, but there is little research to validate that.

5.4 NHK's approaches to touch presentation technology

At NHK, research is underway into multimodal presentation methods that use both audio guides and touch presentation, aimed at data broadcasting and EPGs. A touch navigation method and a tactile display provided with an optical touch panel, which have been developed by NHK, are shown in Figures 4 and 5.

Touch navigation is a tactile interface that presents the patterns of elements such as selection buttons, hierarchical structures, and EPGs by raising and lowering movable actuators that have a switching function, to enable interactive operation. The objective is to make it possible to provide an effective GUI navigation method at a low cost, even for people who are not familiar with PCs. With the tactile display with optical touch panel, visually-impaired people can confirm details by audio or Braille, while navigating the GUI interactively and touching the visual content. We are also developing algorithms to create real-time Braille output of menu selection buttons for data broadcasting and text data in documents.

There is also ongoing evaluation research relating to the use of touch presentation devices for GUI navigation, from the viewpoints of information reception, perception and learning. For example, we have evaluated comparisons of search times with touch navigation or audio navigation, and whether a hierarchical structure is effective. The effectiveness of touch navigation is implied from the results of objective and subjective evaluations. We are also studying placement conditions for making objects such as GUI screens and tables easy to perceive. In addition, studies are continuing into the use of psychophysical experiments to evaluate the effects on short-term memory due to the additional use of touch, to obtain effective presentation conditions.

6. New Research into Information Transmission by Haptic Presentation --- From Plane to Space ---

In the past, haptic presentation technology has been the subject of a great deal of research and development in the games and virtual reality fields. The goal is to give the user an impression that is close to that of touching a real object, such as solidity, the sense of material properties, and the sense of weight, from a distant location or in a virtual environment. We can also consider using it to touch objects such as the structure of the universe or molecules, which cannot be touched in real life. In the future, it is possible that this will lead to the development of spatial recreation media that combine visual and aural information, which could result in a huge information revolution regardless of whether or not the users have disabilities. In this section, we describe technology for presenting three-dimensional information by haptic presentation devices, which are expected to find application in information barrier-free systems and also act as new information transmission means.

6.1 Three-dimensional information presentation devices

One method of presenting solidity or texture that could be considered is to calculate a reaction force in response to the user's operation, and apply it physically to a finger or other part of the user's body. Various methods of presenting this reaction force are being developed, such as the tension of a wire, air pressure, and the moment of inertia of a rotating object. The types of device that are fixed to the floor or desk for use (grounded devices) are characterized in being able to present comparatively large forces with good accuracy. In addition to the finger

16: A chart created by raised and inset areas on a medium such as paper, which a user can comprehend by touching.

17: Mental load is the psychological and physical load imposed on the user by factors such as operating devices.

sack and stylus,[18] that are commonly used, the development and trials of other attachments such as scissors or a scalpel, are underway into their application to remote medical care and surgery simulation purposes. There has recently been a great deal of research into using the vibrators described in Section 4 or a pin array in combination with touch presentation technology, to present feelings such as a sense of force or texture to the fingertips simultaneously.

Devices for imparting the feeling that a number of fingers (multi-fingers) are holding an object have been researched at a number of places in the past, such as devices using wires and also devices that use an exoskeleton method that covers the entire hand and gives each finger a feeling of force. There are various problems to solve, such as the magnitude, precision, and feeling of restraint of the forces. A multi-finger force-sensation presentation device has also been proposed, which has robot hands and fingers that move in linkage with the arms and fingers of the user, and presents reaction forces to the fingers. This makes it possible to present not just the shape of a virtual object but also a sense of the object's weight, and there are ingenious mechanisms to reduce any feeling of restraint or pressure.

There have been reports of a device presents a sense of force by wires from a device worn on the back, as a non-grounded portable haptic presentation device that is envisioned for use in mobile situations. Since the reaction forces are borne by the user himself, unlike with a grounded device, it was a challenge to implement the feeling of exerting forces on external objects and receiving forces from external objects. The emphasis is now on developing a method that uses an illusion created by the non-linear characteristics of human perception, to impart a false feeling of force by applying time lags and periodically repeating large and small accelerations. In addition, a method of using two eccentric rotators[19] makes it possible to present torque and translational forces[20] simultaneously. Such devices have been reduced in size to about the same size as fingertips, so they can be considered for use in amusement devices such as game controllers that enable a sense of force, or in providing walking assistance to visually-impaired people. Note that these portable devices can also be considered in applications which interact with broadcast content or enable GUI operation.

Other research includes that into physically re-creating the shape of an object such as a balloon by air pressure, and the emphasis is on future developments by the fostering of component technologies such as those of new materials.

6.2 Trends in application and perception experiments, etc

The clarification of human perception characteristics and the development of new presentation devices are proceeding hand-in-hand, and there is increasing research into clarifying the relationships between different modalities (senses) such as sight and the touch/force sense. In addition, applications have been developed and experimental evaluation is progressing, with the goal of taking advantage of the interactive capabilities of a touch/force sense presentation device, as described in Section 5, to transmit details such as the colors and composition of graphs and images to visually-impaired people.

A multi-sensory interaction system that conveys information to the five senses integrates a number of sensory information sources such as those of sight, hearing, and touch, to re-create objects such as precious cultural assets in a virtual manner. With a real-time real-world virtual contact system, visual information about an object can be converted into tactile information in real time, to enable the object to be touched in a virtual world. Experiments to enable users to touch an object or phenomenon that is usually difficult to touch raise the possibility of huge changes in the information presentation environment by the implementation of applications such as touch galleries that are not just for visually-impaired people but also for able-bodied people.

In the transmission of solid images, there is currently much research into using illusions based on the superiority of the sense of sight. In applying this to information barrier-free systems, there are challenges involved with determining how this information can be conveyed by just the touch/force senses, but the resolution of such problems will probably be the foundation of technology for presenting an ultra-realistic environment to the five senses.

6.3 Approaches to haptic presentation technology at NHK

At NHK, we are conducting research relating to perception of the shapes of three-dimensional objects, as part of our research into information barrier-free touch presentation technologies. Up until now, we have evaluated details such as how the ease of perception varies with differences in ways of touching and the presentation method, when transmitting a solid shape by touch/force senses alone. We conducted evaluation experiments using point-contact presentation devices and found that it is easier to perceive the shape of a virtual

18: Pen-shaped input-output device.

19: Rotating body with offset center of gravity.

20: A force that causes a parallel movement (translational movement), without rotating the object.

object by touching it from the inside than by touching it from the outside, and that such an object tends to feel larger. In particular, it is thought that the use of a point-contact device causes problems in that the fingers slip away from the corners of the object when the fingers are touching it from the outside, and it is difficult to touch conical parts (projecting parts). In addition, it has been suggested that when there is no visual information, the direction and hardness of the presented virtual object greatly affect perception of shape. We are currently prototyping an experimental device that presents the sense of force to multiple fingers of both hands, and are evaluating the effects of presentation to multiple fingers in the comprehension of solid shapes, and studying effective presentation methods (Figure 6). With a method of using a number of point-contact devices, we found it becomes easier to comprehend edge length and overall size, but also found that it is not always easier to comprehend the characteristic points of the object (such as vertices and sides) or perceive the overall shape. It has been suggested that it is possible that the illusion of touch should be emphasized when investigating presentation methods, such as a tendency for the perception of size to differ with the number of fingers that are used, so further validation is necessary.

In the future, we will study the possibility of information transmission by three-dimensional touch/force sense presentation devices, from the viewpoint of making the information barrier-free systems more universal.

Figure 6: Virtual object shape perception experiment by haptic presentation to multiple fingers of both hands

7. Future Expansion

In this article, we discussed the current state of information barrier-free systems for visually-impaired people in broadcasting and communications, followed research trends in touch presentation technologies, and introduced haptic presentation technologies that can also be used more universally in the future for multi-sense broadcasting. As multimedia becomes more common for broadcast content and visual content is used more often, it will become necessary in the future to research accessibility support technologies that feature audio, enabling correspondence with the description of a wide range of content. However, with conventional audio text-reading alone, people with visual disabilities are finding it difficult to get sufficient assistance. The importance of support technology enabled by a multimodal approach in combination with the sense of touch is increasing, which is expected to be reflected in the results of research into touch presentation technology.

With information transmission from a multimodal approach involving touch and hearing, it is important to concentrate not just on the development of hardware such as devices, but also clarify tactile perception characteristics and the information reception, perception, and learning characteristics of humans, to develop the most effective presentation method. Vital research challenges include clarification of the mechanisms of perceiving maps and graphs facilitated by touch presentation and also the perception of solid shapes, to establish easy-to-comprehend presentation methods and appropriate content-conversion methods. Since these research projects raise the possibility of dramatic advances in the informational environment of visually-impaired people, and also the development of spatial re-creation media by a more universal form of information presentation to the senses, they will be challenges to be pursued further in the future.

Broadcasting is close to being completely digital. We would like to continue our research, hoping to enable even people who have visual disabilities to enjoy watching broadcasts.

(Tadahiro Sakai and Takuya Handa)

Challenge

Series: New Recording Technologies for Broadcasting

New Recording Technologies for Broadcasting

Naoto Hayashi, Senior Research Engineer,
Imaging & Storage Devices Research Division

Tapeless Broadcasting Stations

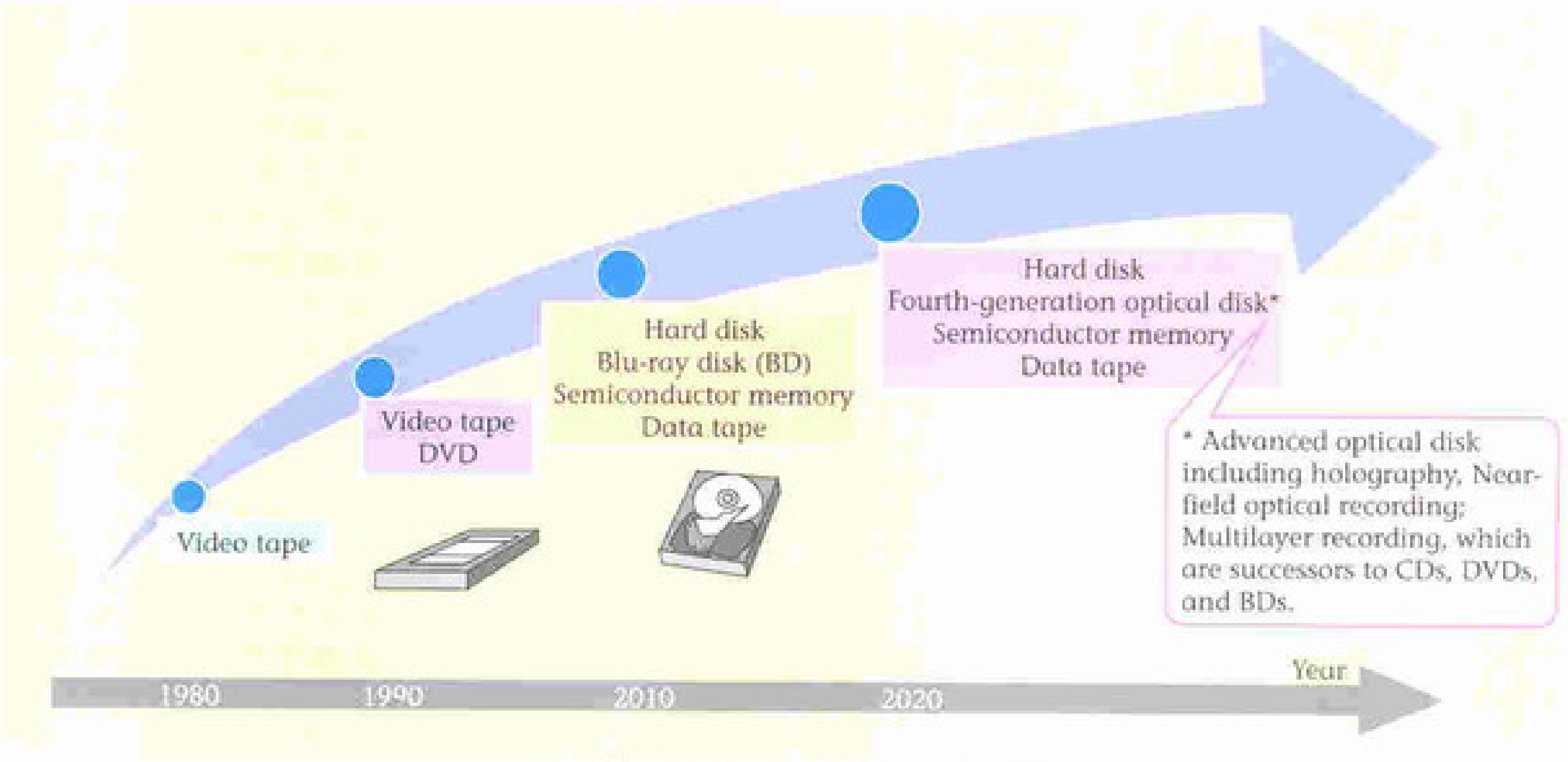
In Japan, the transition from analog to digital terrestrial TV broadcasting will be completed by July 2011. Many broadcasting stations are planning to upgrade their inter-station systems into all-digital systems to coincide with either the transition or as a scheduled upgrade of their core system. These upgrades will turn their systems into "tapeless stations." A "tapeless" system replaces the conventional videotapes used to produce and transmit programs within a broadcasting station with a new system based on hard disk drives (HDDs), semi-conductor memories, or optical disks. This will allow the construction of an inter-station system consisting of video servers and connecting networks, enabling higher-efficiency program production and transmission through the much more flexible recording devices and transfer of data files of program content.

Rapid Evolution of Recording Media

A broadcasting station requires recording devices to store, utilize, and archive program content. Since the release of a practical VCR system in 1956, VCRs and magnetic tapes have been employed for video recording. Since then, VCR systems were reduced in size and were upgraded to support HDTV. Digitalization of these systems proceeded after 1985. Home video recording media during this period used 1/2-inch and 8 mm video tape.

The race in recent years to attain higher-speed, larger-capacity recording media has led to HDDs, optical disks, such as DVD and Blu-ray, and semiconductor memory, as well as to better image compression technology. These advances have made it feasible to record long HDTV video programs on other recording media besides video tape. The fact that these new media are also capable of random access and have good compatibility with communication networks is another reason for their incorporation into a tapeless inter-station system.

The Science & Technology Research Laboratories are researching a compact, high-speed HDD for video, a holographic recording system to support tapeless systems, and a recording system that will have the massive capacity and high speed needed for making and broadcasting Super Hi-Vision programs.



Video recording media transition