Stick-on Communicator and Its Broadband Applications—A Compact Wireless Device with a Built-in Sensor and Actuator Connecting the Real World and the Network

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Abstract

The Stick-on Communicator (StiC) is a compact wireless device with a built-in sensor and actuator that can be attached to any real-world object including a person. It has an adaptive sensing function that enables control of processing parameters for sensing to be controlled via the network and a precise location-detection function using infrared light. These functions enables flexible value-added sensing services that faithfully reflect real-world situations. New broadband + ubiquitous services provided by combining real video images with information obtained from StiCs will lead to an advanced communication style that enables easy and natural access to remote objects.

1. Introduction

As the broadband network continues to expand through the introduction of ADSL (asymmetric digital subscriber line), FTTH (fiber to the home), and other types of connections, a diverse array of large-capacity, high-speed video delivery services is becoming available. However, these services are limited to the delivery of video data in only one direction, such as the delivery of stored video content, video from Web cameras, and live video of music concerts. In short, the inherent bidirectional nature of networks has not yet been used to advantage. Meanwhile, there has been heightened anticipation for ubiquitous services in recent years as more attention is placed on the customer through anytime/anywhere "context-aware" services. The aim here is to provide optimal services for each and every person by determining and analyzing the current state, behavior, and preferences of people and/or things via a large number of sensors connected to the network. As shown in **Fig. 1**, the convergence of ubiquitous features with

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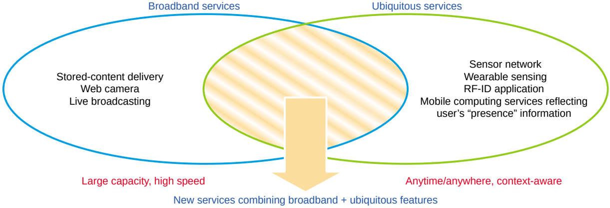


Fig. 1. New-service directions.

existing broadband services suggests the possibility of "broadband + ubiquitous" services that go beyond the conventional unidirectional video-delivery framework. Such services could provide a high level of interaction between the customer and service provider and reflect the tastes and desires of individual users in a natural manner.

2. Stick-on communicator

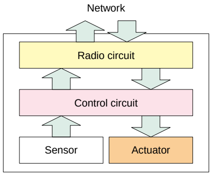
The Stick-on Communicator (StiC) is a compact wireless device with a built-in sensor and actuator that can be attached to any real-world object including a person. It features an adaptive sensing function, which enables processing parameters for sensing to be controlled via the network, and a precise-location-detection function using infrared light. These functions enable flexible value-added sensing services that faithfully reflect real-world situations. This article introduces the concept of "touching remote objects" by delivering information obtained by StiCs along with real video images, which is one way that ubiquitous technologies can contribute to the promotion of broadband services. By "touching" we mean i) obtaining sensing data that could not be obtained from only video images and ii) interacting with actual people and things in a physical manner. The idea here is not simply to enable remote video viewing of actual objects located elsewhere, but to enable someone to communicate with any of them bi-directionally via a network.

The StiC acts as a network sensor and/or an actuator. As a sensor, it can obtain the current state of the object to which it is affixed and that of the object's surroundings in real time. As an actuator, it enables physical interaction with that object.

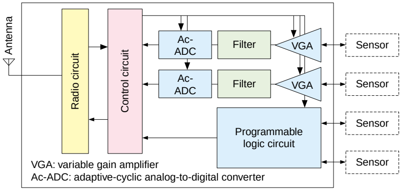
2.1 StiC configuration

Figure 2(a) shows the basic StiC configuration. A StiC consists of a sensor or an actuator as desired, a radio circuit for communicating with other StiCs and a control circuit for controlling all operations. For low-power consumption, it uses a 315-MHz radio unit, which uses a lower frequency band than wireless LANs and Bluetooth. The radio unit communicates with access points on a TCP/IP network using a wireless-communications protocol that we developed, and it exchanges data with personal computers and other devices on the network. A StiC therefore makes it possible to acquire information about persons or things to which it is attached and information about the objects' surroundings, and it sends the information to the network.

Figure 2(b) shows a StiC system configuration for greater adaptability to various usage scenarios. Most network-sensor applications to date perform some kind of sensing by a predetermined fixed operation and send the sensing results to pre-determined users. In the coming ubiquitous era, however, we can envision the use of many sensors by many users for various purposes. In this environment, it will become increasingly important that the sensing operation is not fixed but is adaptive to current conditions and needs. As shown in the figure, this StiC configuration allows important processing parameters for sensing (e.g., amplification and sampling frequency in analog-to-digital conversion) to be set over the network in real time. In short, StiCs make it possible to set optimal, real-world sensing conditions in real time in accordance with peripheral conditions and/or user needs. This capability enables the provision of flexible sensing services that reflect the real world via the network.



(a) Basic configuration



(b) Network-adaptive configuration

Fig. 2. Stick-on Communicator configurations.

3. Concept of a video service using StiC

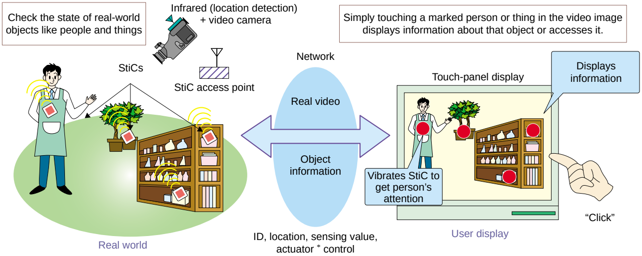
3.1 System overview

This section introduces the "touching remote objects" system (**Fig. 3**) as an example of a broadband + ubiquitous service using StiCs. This system provides the user with the means of communicating bidirectionally with remote objects in the real world. First, the system detects the presence of StiCs attached to real objects and delivers information about those objects via the network together with a real video image. The user can simply "click" on the marker corresponding to an object of interest in the video image displayed on the touch panel. This simple operation displays previously registered information or real-time sensing information about that object, or interacts with the actuator in the StiC. In this way, the system enables even users unfamiliar with computer operations to interact with remote objects in the real world in a straightforward intuitive manner.

3.2 Location detection function

To overlay clickable markers on objects in the video display, the system needs the coordinates of each real object in the camera's field of vision. This location-detection function is outlined in **Fig. 4**. The infrared camera detects infrared light emitted from the StiC having the ID number of interest. Then, using the output signal from the image sensor in the camera, it computes the coordinates of the light-emitting point from the received-light intensity and extracts the location of the person or thing in the camera's field of vision in real time. Some conventional image-filtering techniques are used to suppress the influence of noise caused by infrared from sunlight, remote control units, and so on.

This function can perform high-speed recognition at a rate of about 50 IDs per second (including moving objects) and it is possible to detect the location of



* A device such as a light-emitting diode, speaker, or vibrator that provides physical interaction when an electrical signal is applied.

Fig. 3. A configuration of the "touching remote objects" system.

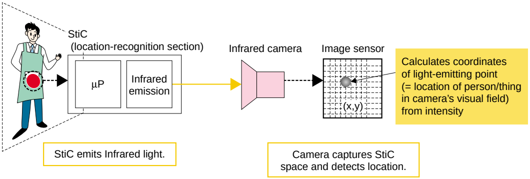


Fig. 4. Outline of the location-detection function.

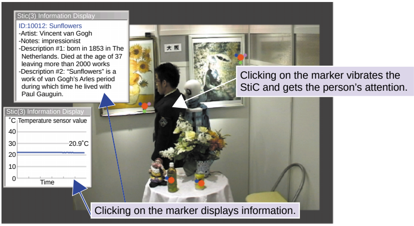


Fig. 5. Demonstration scene.

about 100 real objects within the field of vision. The system can therefore obtain detailed information about almost all objects in a room, including an object's whereabouts and the history of its movement.

3.3 Demonstration example

Figure 5 shows a demonstration of the "touching remote objects" system, where the system is delivering real video of a remote scene over the network and displaying that video in real time on the touch-panel display for the user. At the remote location shown, StiCs are attached to various objects including paintings hanging from the wall, soft-drink bottles and cans on the table, and a human being. The system displays a marker over each of those objects on the display. As shown in **Fig. 6**, clicking on a marker can display attribute information about that person or thing, provide sensing values, or trigger the actuator. In the scene shown in Fig. 5, the user has clicked on the marker corresponding to a painting, resulting in the display of attribute information (a description of the painting). The user has also clicked on a bottle's get-sensing-value tag, resulting in the display of real-time temperature information. The user could also click on the marker near the man's shoulder to get his attention, just like saying "excuse me" in real life. The actuator on his StiC activates a vibrator. Thus, the system effectively lets you call out to a person appearing in the video.

3.4 Potential application fields

Figure 7 shows two examples of application fields envisioned for the StiC. **Figure 7(a)** shows how StiCs could be applied to art galleries, museums, and aquariums to enable remote browsing of works in an exhib-

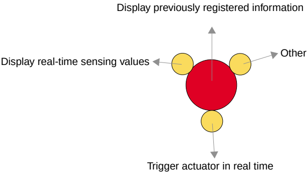


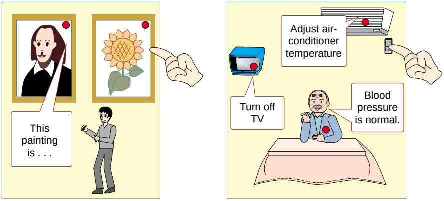
Fig. 6. Example of marker operation.

it and the creation of a remote study program linked to those works. **Figure 7(b)** shows an example of a remote nursing/care system in which the user is able to determine current room conditions and even operate electrical appliances in the room.

In addition, by linking an object's attribute information with information in product tags (such as RFID tags) used for tracing and delivering that information together with video images, we envision the application of StiCs to advanced quality-control processes. In the distribution of fresh food, for example, a user could obtain changes in storage conditions from sensors together with a video feed in real time while referencing product information stored in the product tags of that food.

4. Conclusion

StiC is a compact device that connects the real world with the network. It features adaptive sensing and precise-location-detection functions. It supports the concept of new broadband + ubiquitous services obtained by combining real video images and the



(a) Remote art gallery

(b) Remote nursing/care system

Fig. 7. Application examples.

information obtained from StiCs. The keys to making StiCs practical in everyday life are a compact device configuration and long-term operation. NTT Microsystem Integration Laboratories will research and develop ways of reducing StiC power consumption first by introducing low-voltage circuit technologies and power-management techniques and then by investigating the use of natural energy sources, such as light, heat, and vibration.

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