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Magrid Surface: An interactive display that varies the information by an attached magnetic object

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***Abstract*—This paper presents a vertical interactive surface that can put out both analog and digital information and that can be used as a digital signage and community board in public spaces. Our proposed system uses a magnetic object to not only attach the analog information but also control the digital information. In this system, by attaching the object to the system surface directly, digital information appears. In addition, the system can selectively display the digital information by changing the level of importance. Our system uses multiple wavelengths of infrared light to achieve this function.**

***Keywords*-interactive display; multiple infrared light; magnet; digital signage;**

I. Introduction

There are many surfaces in our surroundings, such as wall, floor, and tabletop. Such surfaces are used as media for displaying information and can be seen in all places. For example, posters and announcement papers are attached to office walls, and many texts are written as memos on whiteboards. Even though many types of information have been digitized currently, *analog* media such as printed posters, brochures, and handwritten memos are still used commonly. In such an environment, we sometimes face certain problems: there may be difficulty in obtaining particular information from an analog medium because too many pieces of paper would have been attached onto the surface, or we cannot determine whether the information is up-to-date or not because the papers would have been arbitrarily attached to a surface in a random order.

In addition, such old-fashioned wall media do not handle image/video information. Using a large digital display can solve the problem; however, these analog media still play an important role in our daily life. In the current situation, such digital display does not handle both analog and digital information simultaneously because it is difficult for the digital display to hook the analog information. If a user scans and digitizes the analog data to display them in digital, both types of data can be handled in a unified manner, however, the merits of analog media (e.g., easy to attach/remove the paper and easy to add a handwritten memo on the surface) disappear.

In this research, we have addressed the abovementioned problem by enhancing the surface such that it can handle both digital and analog media simultaneously. The proposed surface, Magrid Surface, uses magnets to control the digital information. The analog media such as papers are easily attached on the surface physically by using the magnets.

II. Related Works

A various large interactive surfaces such as tabletop systems [1] and wall systems [2], [3] have been proposed. These systems are intended to facilitate information sharing among multiple users easily.

Many tabletop systems enable control of the displayed information by using objects placed on the tabletop.

SLAP widgets [4] are physical user interface components that are intended to be used on tabletop systems. The physical widgets of SLAP are made from silicone rubber and acrylic boards. By using these widgets, the user can easily control the displayed digital information.

Tablescape Plus [5] is another tabletop system that utilizes physical objects to manipulate the information displayed on its surface: This system uses tiny objects made of plastic. By placing an object on the surface, the system projects an image on the object's surface behind the screen. By this function, not only the surface of the tabletop but also the surface of the object placed on the screen becomes an information display, and these two displays present information with concerted efforts.

These tabletop systems can easily handle both digital and analog information because these systems comprise horizontal spaces (i.e., tabletop surface), and various types of objects can be placed on the table.

In the case of vertical information display, in contrast, it is difficult to use physical objects because of gravitational pull. Some of the previous systems had attempted to solve this problem. Voodoo interface [6] is an interface that can attach a physical object onto the surface: the object has a pin shape and can be stuck to the surface. The surface consists of several layers, and one of the layers is an electrode layer. By sticking the object, the system detects whether the object is stuck or not and specifies the position of the stuck object via the electrode layer.

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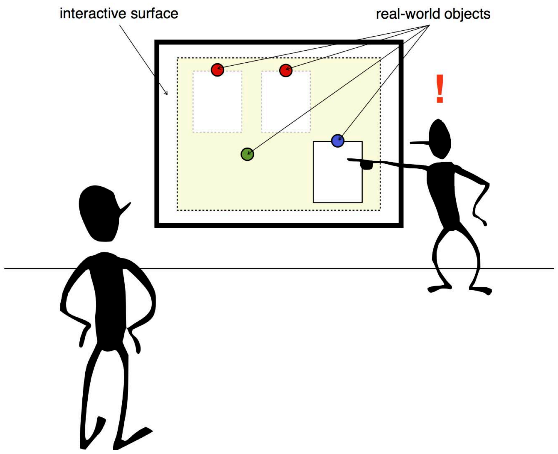

Figure 1. System concept

However, because of the screen structure, this system is not suited for the rear-projection method. This implies that this system only permits front-projection method and, therefore, cannot avoid the occlusion problem caused by a user standing in front of the system.

We propose a novel display system that satisfies the two conflicting requirements under the vertical display setting, that is, the system attaches the objects on the surface and adopts the rear-projection method. The next section describes our system.

III. Proposed System

This section describes the concept and configuration of our proposed system named Magrid Surface.

A. Concept

Magrid Surface is a vertical interactive surface, which is assumed to be located in a public space such in office or school. The system displays information on its surface and permits control of the information by using physical objects attached to the surface.

An outline of the system is shown in Figure 1. This system uses physical objects that can be attached to the vertical surface as mentioned above. The object has three functions, that is, to attach analog information (e.g., post card and sheet of brochure) onto the surface, to display digital information (e.g., movie, picture), and to control the digital information (e.g., attach, move and remove). As shown in this figure, the information attached to display at the lower right is analog and the remaining are digital.

These functions allow the users to handle both analog and digital information in the same manner: Similar to the case of analog media, when a physical object is attached to the interactive surface, the digital information appears under the object, and the information dropped off when the object is removed. This implies that the proposed system achieves consistency in the operation, regardless of whether the media are digital or analog.

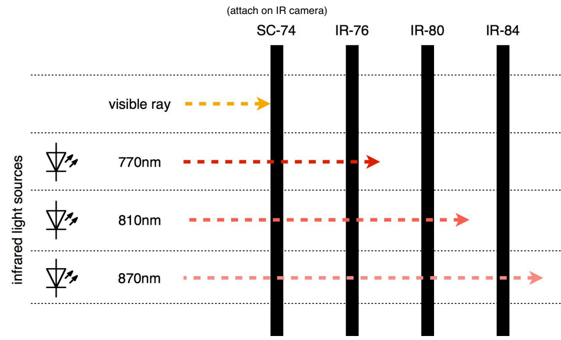

Figure 2. Characteristics of IR filters

B. System Configuration

The proposed system adopts a form of projector-camera configuration. A projector is installed behind the system's screen (i.e., rear-projection method). Many interactive surfaces, in the previous studies, used the front-projection method with ease. However, when a user stands in front of the system, the projected information is shaded by the user's shadow, and, therefore, there is user inconvenience while using the system. Therefore, in the proposed system, the rear-projection method is employed to avoid such occlusion problems.

Physical objects comprising magnets are used for system interaction. In each of these objects, a visible-light cut-off filter (hereafter, infrared (IR) filter) is attached to the surface of the magnet. The IR filter has a function that transmits light over a specific wavelength of the IR region and prevents transmission of visible light.

A wire net made of magnetic stainless steel is used as the screen material. The screen is radiated by IR light of multiple wavelengths from behind the screen. It is possible to vary the wavelength.

By using this configuration, the magnetic objects can be attached on the screen, and further, the system can determine the positions of the objects by detecting the IR light reflected by the attached objects. When attaching the magnetic objects on the surface, the system displays the digital information on the screen, and the information disappears when the magnet is removed from the surface. Moreover, the "level of importance," which intends to filter information based on the imporance of displayed information, can be controlled by the wavelength of radiated IR light: When the "level of importance" is high, only a set of limited information (i.e., only important information) appears. In contrast, when the "level of importance" is low, the entire information appears.

IV. Material Selection

For the development of the proposed system, it is necessary to choose appropriate materials. This section describes the condition and examination required for material selection.

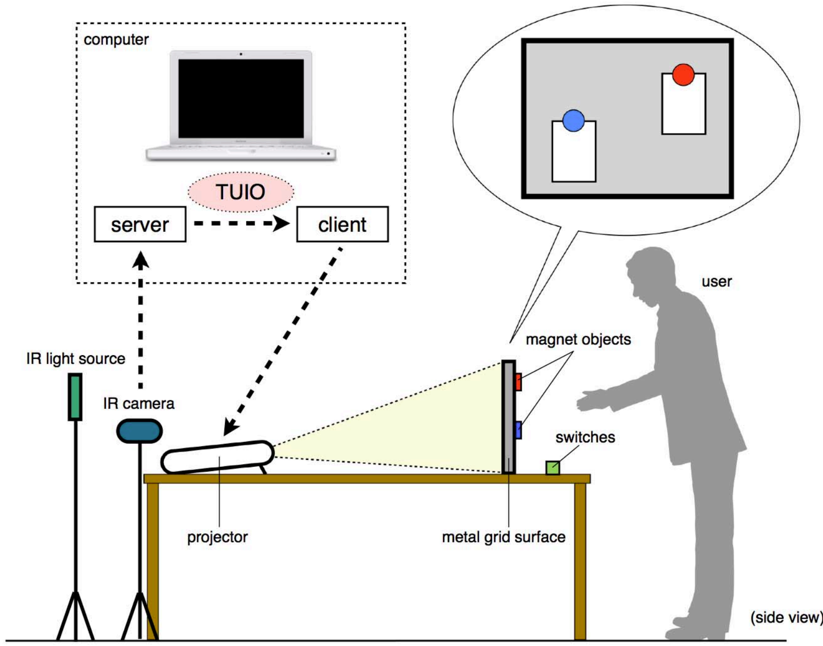

Figure 3. System structure

A. IR Light and IR Filter

In this system, there are several types of magnets used to discriminate the information displayed. In this system, the concept of "level of importance" is introduced. Some information is hidden when the "level of importance" is high. The user can control the information according to their preference of whether the information should be visible or not.

For discriminating the magnet types, several types of IR filters are attached on the surface of each of the magnet. The user can control the level of importance by varying the wavelength of the emitted light.

For this purpose, the proposed system uses four filters (SC-74, IR-76, IR-80, and IR-84), which are attached to a retroreflective material and illuminated with three wavelengths: 770, 810, 870 (see Figure 2). The relationship between the filters and the light sources is as follows: When the IR filters are illuminated with a 700-nm light, the light is blocked by all the filters except the SC-74 filter, which transmits the light. In the case of an 810-nm light, the SC-74 filter and IR-76 filter transmit the light, while the IR-80 filter and IR-84 filter block the light. For an 870-nm light, the IR-80 filter and shorter-wavelength filters transmit the light, and the IR-84 filter and longer-wavelength filters block the light. Illumination with an 870-nm light results in the light being transmitted by the all IR filters.

In our proposed system, it is necessary to choose the filters that offer a clear difference in transmission when the wavelengths are varied. Thus, we have selected the SC-74, IR-78, IR-82, and IR-90 filters to block the four wavelengths, 700, 770, 810, and 870 nm, respectively.

Table I
MESH WIRES USED IN THE EXPERIMENT

Type	ϕ (mm)	Aperture	# of Mesh	Free Area Ratio (%)
Net A	0.50	1.09	16/in.	47.00
Net B	0.29	1.12	18/in.	63.10
Net C	0.35	0.92	20/in.	52.48

B. Screen Surface Material

As mentioned above, the system adopts the rear projection method. There are two requirements for the screen: (1) clear visibility under the rear projection condition and (2) magnet-attachable surface.

In order to satisfy these requirements, this system uses a magnetic stainless steel wire net for the screen surface.

First, we have verified the clarity of the projected image by varying the mesh size of the surface. Table I summarizes the wire nets selected as the screen candidates. On these screen candidates, SMPTE color bar is projected by a projector (CASIO Laser Projector XJ-A130, 2000 lumen) at a distance of 1000 mm away from the screen. We have compared these screen candidates by observation and found that the visibility of net A is inferior to those of net B and net C. On the basis of this, net A is eliminated.

Second, we have verified the magnetic attachability of the surface. When the free area ratio of the wire net is very high, it is not suited as a base to attach a magnetic object because the contact area becomes too small. From this perspective, net B is found to be inferior to net C.

On the basis of this investigation, the Magrid Surface employs net C as the screen material.

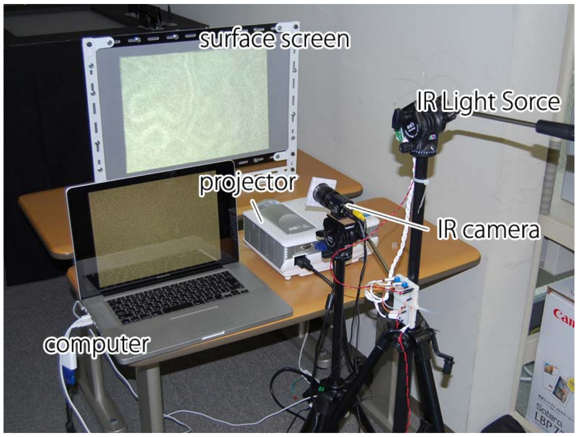

Figure 4. System overview (behind the screen)

V. Prototype System

A. Hardware Configuration

The proposed system adopts a projector-camera construction. Our prototype system consists of a surface comprising a magnetic stainless steel wire net, magnetic objects, IR light source, IR cameras, a projector, and a computer.

The structure and overview of the prototype system are shown in Figure 3 and Figure 4, respectively.

1) Surface Configuration: In our prototype system, we use a 20-mesh magnetic stainless steel wire net on the basis of the result of the examination described in the previous section. The surface of the net is coated by matte gray paints to prevent unexpected reflection that harms object recognition.

For amplifying the brightness of the image, a tracing paper (Sakurai, Star Trace T-808, 50 g/m^2) is attached on the wire net.

2) Magnetic Objects: In each magnet, a retroreflective sheet and an IR filter are attached to discriminate the magnet types.

The screen of the Magrid Surface consists of two components: a wire net and a tracing paper. The magnetic contact-area of the wire net is limited because of the mesh texture. Furthermore, retroreflective sheet and IR filter are attached on the surface of the magnetic object. Therefore, it is difficult to attach generally used magnets on the surface under the vertical surface condition; magnets drop off easily. In order to firmly attach the magnet to the surface, a strong magnetic force is required.

In order to overcome the above problem, we have disassembled the generally used magnet and embedded a strong neodymium magnet instead, such that a strong magnet force is ensured.

Three types of IR filters, IR-76, IR-80, and IR-84, are used. The structure of the magnetic object is shown in Figure 5.

3) IR Light Source: As a light source, an IR LED array that consists of three types of IR LEDs is used. We have used 10 IR LEDs in each, whose peak emission wavelengths are 770nm, 810nm, and 870nm. The irradiation range and intensity of the IR light depends on the types of IR LEDs used. In order to maintain these aspects (i.e., radiated area and brightness) consistently, the intensity is carefully adjusted in advance.

4) IR Camera: This prototype system uses a high-sensitivity CCD camera (Watec, WAT-902-H-ULTIMATE) with near-IR compliant lens (TAMRON, 12VM412ASIR). An IR filter (FUJIFILM, SC-74) that transmits light over 740-nm wavelength is attached on the lens to capture only the IR image. According to the capturing mode of the camera, the low gamma-correction mode is chosen because the acquired images are too obscure in the canonical mode.

The image captured by the camera has a resolution of 640×480 pixels.

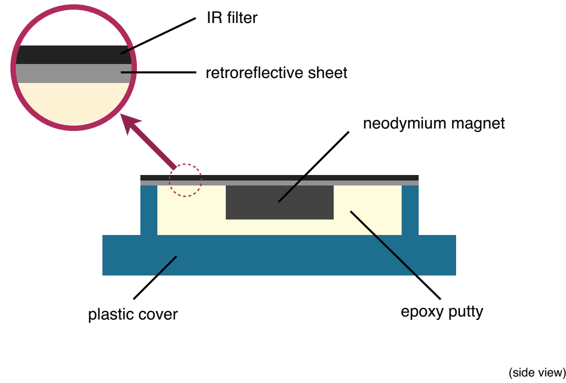

Figure 5. Magnetic object structure

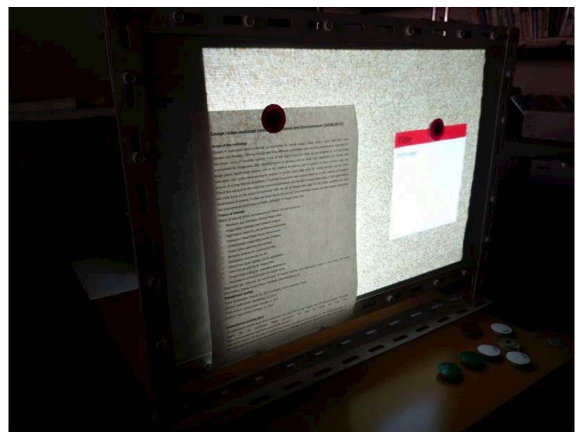

Figure 6. Analog and digital information attached to Magrid Surface (left: paper media as analog information, right: digital information)

B. Software Configuration

This process is classified into two types. One is to determine the position of the attached magnetic object by capturing the IR cameras, and the other is to project the image in accordance with the determined position of the magnetic object.

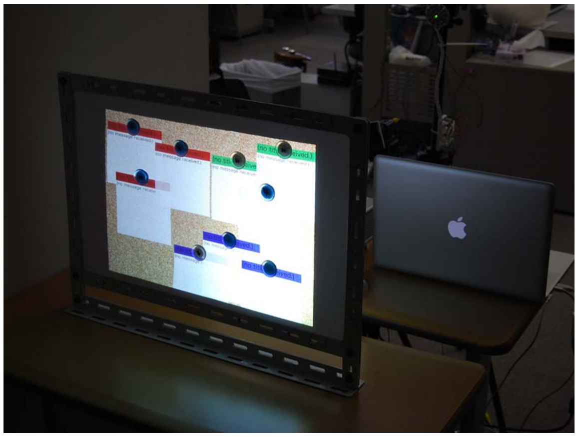

Figure 7. Application snapshot (when 770-nm light is irradiated)

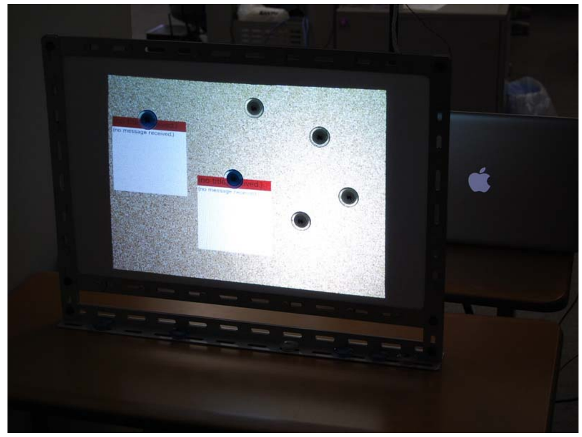

Figure 8. Application snapshot (when 870-nm light is irradiated)

In the prototype system, the server-side application performs the acquisition of the image, and the client-side application performs the presentation image control. Communication between these two applications is performed by the TUIO protocol, which extends the OSC (Open Sound Control).

As the server-side application, Community Core Vision[1] (hereinafter referred to as CCV), which is a multi-touch recognizing application provided by the NUI Group, is used. CCV transmits the control signal by the TUIO protocol [7] to a certain port address. The distortion correction process was added because the currently used IR cameras exhibit a greater distortion of the lens.

The client-side application controls the image to be displayed on the basis of the coordinates received from the server-side application.

By performing the above configurations, both analog and digital information can be reconciled on a vertical surface (See Figure 6).

C. Selective Image provision

In this prototype system, when a user presses the switch, the IR light irradiation pattern changes.

The snapshots of the application are shown in Figure 7 and Figure 8. Figure 7 shows an image when a 770-nm IR light is irradiated. In this figure, only two windows that include important information are displayed. In contralt, as shown in Figure 8, all windows become visible regardress of importance of information when an 870-nm IR light is irradiated.

As seen in these figures, the number of window varies in accordance with the wavelength irradiated. By using this function, a selective image display is achieved.

VI. Concluding Remarks

This paper proposed a novel vertical interactive surface that can display both analog and digital information. Our proposed system uses a magnetic object to not only attach the analog media but also control the digital information. In this system, by attaching the object to the system surface, the digital display is performed. In addition, the system can selectively display the digital information by changing the level of importance. In order to achieve this function, our system used multiple wavelengths of IR LED. In the near future, we will extend the system to automatically change the level of display with respect to the person standing in front of the system. In addition, we will improve the magnet recognition method to achieve precise discrimination of the magnet types.

Acknowledgment

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