MIRROR APPLIANCE: RECOMMENDATION OF CLOTHES COORDINATION IN DAILY LIFE

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Abstract. We developed a "Mirror Appliance" that is used to recommend various combinations of clothes in order to produce a coordinated look suitable for a given day's events and weather. The system stores information on the user's clothes, weather and the events to which the user previously wore certain clothes. When the user stands in front of the "Mirror Appliance", the system refers to the current weather information, the user's current schedule and the user's past behavior. Using this system, the user can have chosen for him/her the most suitable combination of clothes that reflects his/her preferences.

1. Introduction

The purpose of our research is to support real life in a ubiquitous computing environment. We believe that we can support real life by storing information on our daily activities on a computer in a life log (J. Gemmell et al. 2006) or similar. For example, let us suppose that a user stores his/her behavior and preferences in the user storage area on a network. If the computer system embedded in the environment can recognize the user, it can access the user's storage and support the user.

We developed a "Mirror Appliance" to achieve the above purpose. The "Mirror Appliance" is similar in some ways to a real mirror. However, the developed *mirror* in our system acts as an interface that interacts with users. "Mirror Appliance" can store information of user's daily activities and recommend clothes for the users to wear in a specific day. "Mirror Appliance" can recommend clothes depending on some criteria such as weather, temperature, and user's preferences.

The structure of this paper is as follows. Section 2 gives an overview of the "Mirror Appliance." The functions of the system are described in Section 3. The implementation is described in Section 4. An initial user's study is described in Section 5 and related work in Section 6. A conclusion is drawn and future work detailed in Section 7.

2. Mirror Appliance Overview

Using the system, the user can get the most suitable combination of clothes by just standing in front of the mirror. Figure 1 shows the system overview. When a user stands in front of the system, it will recognize the identity of the user. The system gathers information on the current weather conditions and temperature, the user's schedule for the day and some of the user's past behavior that has been recorded in network storage. By using this information, the system chooses the most suitable combination of clothes for the present time, place, and occasion. It then displays this choice on the mirror surface.

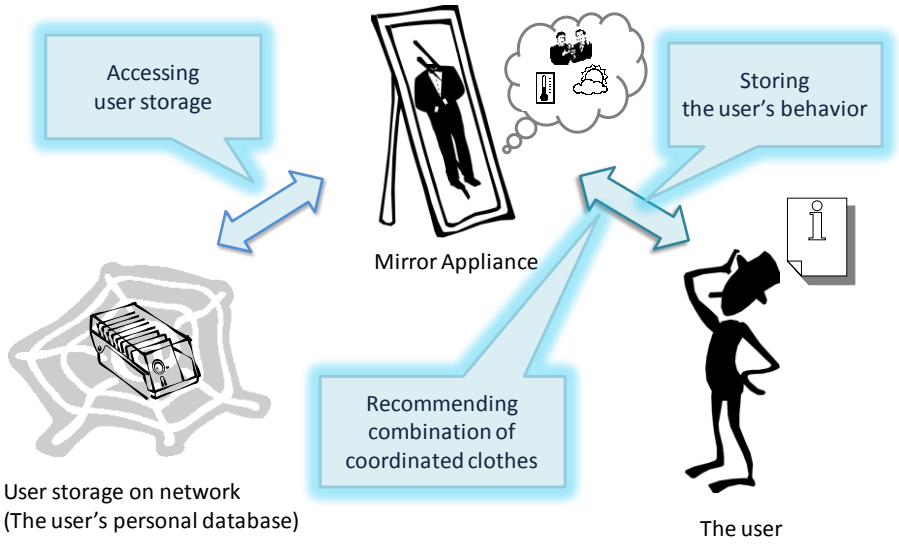

Figure 1. System Overview.

The user's past behavior is recorded in network storage. This means the system is not restricted to one single "Mirror Appliance." Thus, one "Mirror Appliance" can be used for the whole family. In the future, if "Mirror Appliances" are installed in stores, the system can access a user's information over the Internet and recommend combination of clothes for the user while they are shopping, thus helping the user to choose new clothes more effectively.

3. Mirror Appliance

3.1. RECOMMENDATION OF COORDINATED CLOTHES

To get a recommendation for clothes to wear today from the "Mirror Appliance," the user just shows a current schedule marker to the "Mirror Appliance." The system obtains information on the user's past behavior from his/her personal database, refers to the weather forecast for today, and chooeses the most suitable combination of clothes (Figure 2). This combination should also match to user's schedule for that day.

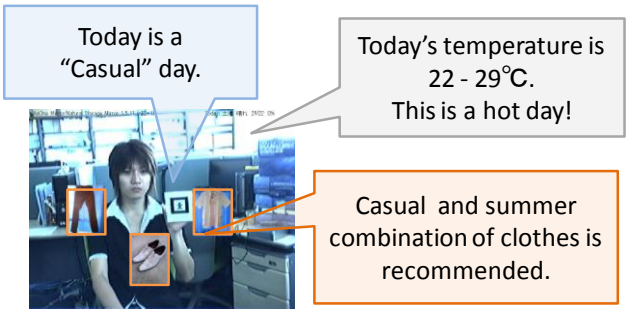

Figure 2. Recommended coordination of clothes.

3.2. INFORMATIOIN THAT IS NECESSARY FOR CHOOSING COMBINATIONS

3.2.1. User's Current Schedule

To get a recommendation from the "Mirror Appliance," the user needs to give his/her schedule for that day to the appliance. We classify a schedule into three categories: "Casual," "Business," and "Formal." The user gives his schedule category to the "Mirror Appliance" by holding a marker up to the mirror. We use "ARToolKit" [1] markers for that purpose. We made three markers: "Casual," "Business" and "Formal" (Figure 3). The "Mirror Appliance" also recognizes the user's identity from the presented marker.

Figure 3. Markers which indicates user's schedule.

1:http://www.hitl.washington.edu/artoolkit

3.2.2. User's Past Events

The user's personal database stores information on past events in the user's life. It has the following information: "which clothes the user wore in the past" and "what was the user activity on that day." In addition, weather and temperature are also recorded. The user inputs this information using a touch panel that is on the surface of the mirror. Figure 4 shows how to store past events. First, a user inputs today's event by touching one of the three event icons (the left-bottom icons in Figure 4). Second, a user touches a clothes icon, which leads to a pops up menu of clothes photos appearing on the mirror (the right five photos in Figure 4). Then, the user drags and drops the photo of the clothes that he/she wore on that to the left window.

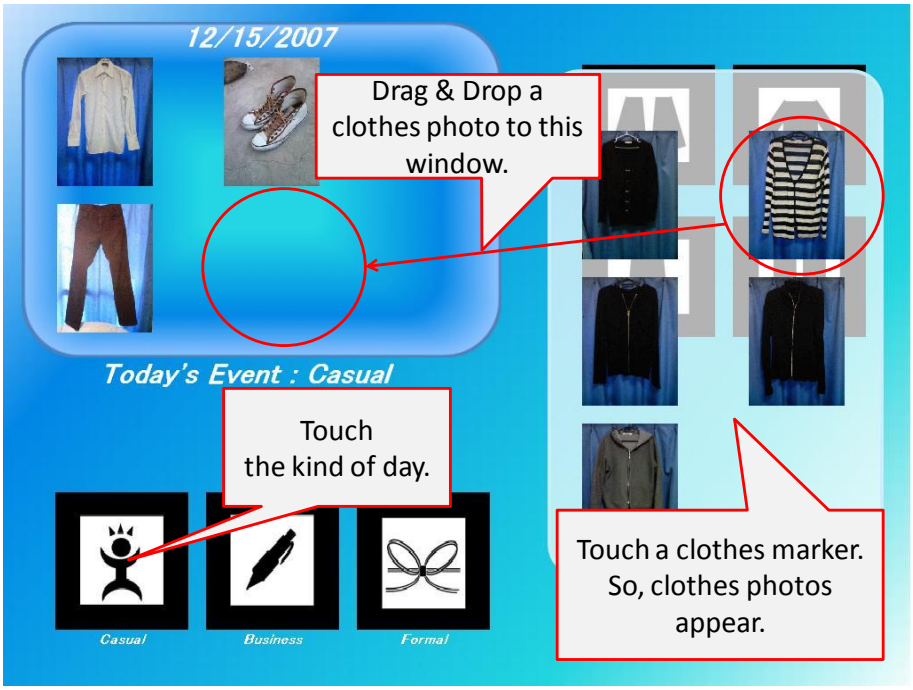

Figure 4. Operation of Input Interface.

3.3. CLOSET FUNCTION

The "Mirror Appliance" not only recommends a combinations of coordinated clothes but also shows a photo of all the user's clothes in his/her closet on the mirror surface. In other words, it is as if a user can take a look at all his/her clothes while still standing in front of a mirror. By showing a clothes marker

to the “Mirror Appliance,” the user can look at photos of “Jackets,” “Shirts,” “Bottoms,” “Shoes” and “Accessories” (Figure 5).

Figure 5 Closet function (Showing Shirts).

4. Implementation

In this section, we describe the “Mirror Appliance” implementation. The “Mirror Appliance” is implemented using Visual C++. We use MySQL for the user storage.

The “Mirror Appliance” uses a large display equipped with a touch panel and a USB camera mounted on it (Figure 6). The USB camera takes video images of the area in front of the display. These images are stretched, and displayed on the large display. Thus the large display behaves like a real mirror.

Figure 6. Appearance of “Mirror Appliance”.

4.1. MARKER DESIGN

The system uses markers as an input devices. The size of each marker is approximately 10 × 10 cm, which is a convenient size. The markers contain a symbol depicting a meaning (Figure 4, Figure 5). A user can easily understand the meaning of each marker. As we described in section 3.1, just by holding a marker up to the "Mirror Appliance," the user can use this system. Therefore, novice users can easily operate.

4.2. RECOMMENDATION ALGORITHM

A user holds up an event marker for today to the "Mirror Appliance." The "Mirror Appliance" determines the user schedule and then accesses the user's personal database. Simultaneously, the system refers to weather and temperature information from a web service. It then chooses clothes from the user's personal database that are suitable for today's weather and schedule. Clothes are often classified by the season, but our system recommends clothes according not to the calendar but to the current temperature (Figure 7). This is because there are "out of season" days such as cold days in summer and hot days in winter. Finally, the system searches for combinations of clothes that the user has worn in the past where each item satisfies today's weather and temperature conditions. The present system can recommend a combination of "Tops," "Bottoms" and "Shoes." The system refers to the date when the user wore these "Tops," "Bottoms" and "Shoes." When the dates that items from "Tops," "Bottoms" and "Shoes" were worn are the same the system recommends that combination because it matches the user's personal preference.

```
Presuming present season
if present lowest temperature > 18 ℃ then
    return recommending summer clothes
else if present highest temperature < 15 ℃ then
    return recommending winter clothes
else
    recommending spring clothes or autumn clothes
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Figure 7. Presuming present season algorithm.

5. Initial User Studies

To evaluate the clothes combination recommendation algorithm, we tested the system from January 2007 to December 2007 on one day (25th) in every month. Table 1 shows information on each of these days. Figure 8 shows an example of the combination of clothes recommended by the system. Before the evaluation, we recorded the behavior of one user for 358 days, from Dec. 24, 2006 to Dec. 15, 2007 (*today*), in the user's personal database. In addition, we entered details on one user's clothes, a total of 72 items, into the user's personal database.

Table 1. Days information.

Date	Weather	Highest temperature	Lowest temperature	Schedule
Jan. 25	Fine	10.6℃	-3.7℃	Business
Feb. 25	Fine/Cloudy	6.7	-2.3	Casual
Mar. 25	Rain→Cloudy	17.1	11.2	Business
Apr. 25	Rain	14.6	10.8	Business
May. 25	Cloudy→Rain	20.7	15.3	Business
June. 25	Cloudy	22.9	18.3	Casual
July. 25	Cloudy/Fine	31.3	18.8	Casual
Aug. 25	Fine	31.5	22.9	Formal
Sep. 25	Fine/Cloudy	29.5	17.5	Business
Oct. 25	Fine→Cloudy	20.4	6.7	Business
Nov. 25	Fine/Cloudy	17.1	-0.9	Business

Figure 8. An example of recommended combination of clothes (Nov. 25).

We examined the combination of clothes recommended by the system. The clothes were appropriate for the current weather, temperature and user's schedule. In addition, we can see the characteristics of the recommended combination of clothes: "Jackets" and "Shirts" are coordinated in pairs. "Bottoms" are coordinated depending on "Tops," and "Shoes" are coordinated depending on weather and schedule. In other words, the combinations of clothes recommended by this system reflect the user's preferences.

6. Related Work

There has been a lot of research on recording the complete behavior of a user, such as Life log, by using such things as cameras and sensors (G.C. de Silva et al. 2005). One problem with this research is that storing information on someone for one year needs 1TB of storage, if we assume, that we use, only 4 hours of video per one day (J. Gemmell et al. 2003). In addition, there may also be a mental burden on the person being watched. In this research, the user uses a simple interface to actively store the information necessary for the system.

There is a web-based system that recommends combinations of coordinated clothes (E. Shen et al. 2007). To use this system, the user stands in front of a computer when he/she chooses clothes. In this research, the user stands in front of a mirror, which is more natural. A mirror is a familiar instrument. Furthermore, mirror is aesthetically and functionally superior to a computer screen. (P. Markopoulos et al. 2006).

7. Conclusion and Future Work

In this research, we developed a "Mirror Appliance" that can support a user in his/her real life. Using this system, a user gets the most suitable combination of coordinated clothes that reflects the user's preferences. In the future, we would like to bring the "Mirror Appliance's" appearance closer to a real mirror. We would also like to improve the recommendation algorithm.

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