Entertaible: Multi-user multi-object concurrent input

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ABSTRACT
Interactive tables are attractive systems that can be used for many different applications. Most of these applications include co-located collaboration with other people. Based on the guidelines of Scott et al. [10] the need for a new input solution is indicated. The input technology of Entertaible is presented, which is based on infrared touch detection to detect multiple concurrent inputs from fingers and objects.

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INTRODUCTION
In recent years interactive tables have received considerable attention. A valuable characteristic of interactive tables is the support it can provide for collaboration in interaction with information. A need for this can be found in domains stretching from office use [12], [5], via education [8], [11] and museums [2], to leisure applications [7].

Each of these applications has their own requirements on the interaction technology and several solutions for interactive tables have been proposed in the past. Some of these solutions are described in the next section.

INPUT TECHNOLOGIES FOR INTERACTIVE TABLES
In their overview, Scott et al. [10] list eight guidelines for co-located collaborative tabletop interactive displays. Five of these guidelines have implications for the input technology that is used.

Two of these five guidelines put restrictions to the impact that the interaction technology may have on the ergonomics of the table. Users should be able to sit comfortably around the table (Guideline 1: 'Support interpersonal interaction'), which means avoiding bulky components under the table. Additionally, users should be able to sit anywhere around the table (Guideline 7: 'Consideration for the appropriate arrangements of users'), implying that input solutions should not occupy or favor one side of the table. A third guideline related to the input technology (Guideline 2: 'Support fluid transitions between activities') prefers universal input devices so that few switches between input devices are required to accomplish tasks. Since several interactive table solutions comply with these three guidelines, they are not further considered in this paper. The two other input technology-related guidelines considerably reduce the number of compliant interactive table solutions: 'Support the use of physical objects' (Guideline 5) and 'Support simultaneous user actions' (Guideline 8).

There are several multi-user concurrent input solutions:

I. Using multiple mice, styli, or similar devices in combination with software that enables multiple concurrent inputs. However, such solutions counteract the natural interpersonal interaction (Guideline 1) since the use of deictic (pointing) references and gestures are not well supported [6].

II. Use special object and sensing combinations (e.g., electromagnetic objects Sensetable [8]). However, such solutions typically require a projection display, which does not lend itself to (bright) day light conditions.

III. Enhancing touch-sensing technologies to detect multiple concurrent inputs as shown by, e.g., DiamondTouch [3] and SmartSkin [9].

IV. Use computer vision-based solutions like the VIP system [1] or DViT [4].

Computer vision-based solutions (IV) and special object and sensing combinations (II) also support the interaction with physical objects well (Guideline 5). This is different for the touch-sensing solutions (III). For example, conductive and capacitive touch sensing solutions require that (a) the objects are made of conductive materials and that (b) the user touches the object to enable the system to 'see' it, which means that a location history needs to be maintained for all (no longer touched) objects.

In spite of the fact that standard computer vision-based solutions (with a view from above the table) as well as the DViT system comply with all guidelines, these too have

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drawbacks. Computer vision-based solutions require controlled light conditions [8] and the cameras of the DViT system can be easily occluded because they are mounted in the corners of a frame that surrounds the display/input area.

ENTERTAIBLE: INFRARED-BASED SOLUTION

Infrared-based touch sensing is a technology that detects objects as well as fingers. The principle of an infrared touch screen is the combination of an infrared (IR) LED and an IR-sensitive photodiode. As soon as there is an object or finger between the LED and the photodiode, the latter no longer detects the IR light from the LED. This information is the basis for the input detection. By using a series of LEDs and photodiodes along the edges of the display multiple objects and fingers can be seen concurrently (see Figure 1).

Figure 1: Detection of multiple concurrent inputs

By using the infrared-based multiple concurrent input detection, Entertaible [13] complies with all the guidelines that Scott at al. have described, without the drawbacks of some of the other solutions:

- There is no need for controlled light conditions as no computer vision or projection display is used.
- Objects do not need to be conductive or otherwise prepared for detection. Of course, objects must block IR light, but almost all objects do.
- The direct interaction of pointing support interpersonal interaction with deictic references and gestures.

Several interactive games have been implemented successfully on the Entertaible, receiving very positive feedback from users. The use of this technology for other applications is promising, but requires further investigation.

CONCLUSION AND FUTURE WORK

In this paper the need for a new interaction solution for interactive tables has been described and an infrared-based solution has been presented. In the future other applications than games will be tested on the Entertaible.

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