# 유도된 상호작용성을 통한 가상환경에서의 현실감 제고

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# Visual Information for Inducing Interactivity and Presence

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요약

가상환경에서의 실재감을 증대 시키는 방법 중의 하나는 상호작용을 이용하는 방법이다. 즉, 사용자가 가상환경에 변화를 줄 수 있게 하여, 사용자와 가상환경 사이의 결속감을 통해, 사용자가 가상환경 속에 있는 듯한 느낌을 주는 것이다. 그러나, Architectural Walkthrough 혹은 Navigation 시스템은 기능적으로 가상객체와의 직접 상호작용이 실제 그리 많이 필요하지 않다. 본 연구는 실제 상호작용이 적은 가상현실에서 가상객체에 affordance 와 그 밖의 interactivity cue 를 적용하여 사용자로 하여금 시각적으로만 상호작용감을 유발 하게 하여, 사용자의 실재감을 높이기 위한 방법에 대한 것이다. 두 개의 가상환경에 대하서, 아무런 visual cue 가 없는 경우, 텍스트를 이용한 직접 표현 방법, 객체가 simulation 된 trace, 그리고 affordance cue 등 총 4 방법들, 즉 총 8 가지 실험 조합에서 사용자가 느끼는 상호작용성과 실재감을 측정하였는데, interactivity 유도를 위한 간접적인 visual cue 가 쓰였을 경우 통계적으로 유의 하게, 상호작용성 및 실재감이 증대하는 결과를 보여주었다. 이는 적은 모델링만의 노력으로, 실제 인터액션에 대한 구현 없이, 가상환경에서 어느 정도의 실재감을 높일 수 있는 방법을 제시하고 있다.

Keyword: 현실감, 상호작용성, Affordance, Virtual Reality

## 1. INTRODUCTION

Many studies on presence have reported that interaction or interactivity with virtual objects (or the virtual environment), plays a significant role in enhancing presence [4][10][17][20]. Interactivity refers to the amount of involvement or capability of the user with respect to experiencing the virtual world. An appropriate design of interaction can increase presence by strengthening the bond between the user and the virtual world.

A question posed to a developer is whether there remains further room for improving the sense of presence by manipulating the aspect of interaction. This paper proposes the use of "Visual Information for inducing Interaction (VII)", which is a collection of direct or indirect visual cues/information to let the user know how the objects might behave or how their behaviors might be initiated, thus induce interactivity (and ultimately the sense of presence) without actual interaction. We emphasize that, at least in this paper, interactivity, is a sense or feeling, while interaction refers to actual and physical transaction between the user and computer (See Section 3 for a more precise definition). That is, VII offers a way to increase the feeling of interactivity without developing a full simulation and interaction models for auxiliary objects in virtual environments.

## 2. RELATED WORK

Presence, or the sense of presence is defined as the degree to which participants feel that they are somewhere other than their physical location because of the effects of a computer-generated simulation [6][10][15][17][20]. The effect is often dubbed as the "sense of being there" [6][17]. Researchers are now categorizing this as "spatial" presence, recognizing that presence is also related to other cognitive properties such as attention and emotion, not just spatial perception from raw sensory input [21][22][23][24]. Our study also focuses on spatial presence only.

Many studies on presence have identified interaction as one of the key components in promoting presence. There also has been a sizable body of work in the 3D and multi-modal interaction and interface design for virtual environments recently (a good review can be found in [2]). However, there are not many in-depth studies on the exact relationship between interaction and the sense of presence. Welch has investigated in the relative benefits between the pictorial realism and interaction factors [19]. His experiment showed that providing interaction was more important than providing a pictorially realistic environment. Few other studies have looked at the effect of different styles of interaction to the level of presence [1][8][9][18].

In some sense, the issue of designing virtual objects themselves for efficient (and perhaps natural) interaction has been overlooked in the virtual reality community. D. Norman, in his seminal book "The Design of Everyday Things", talks about such design criteria that can be applied not only to 2D/3D interfaces, but also to general real (or virtual) products (3D objects) [13]. Those are (1) *affordance*, which is a part of the object that acts as a cue through which users can deduce how to use or manipulate it in an intuitive manner, (2) *consistent mapping* between user and system actions on the target interaction object, and (3) *feedback* that notifies the user that the intended action has been carried out.

While it is nearly impossible to enumerate all the different cases, the following methods of initiating interaction in VE's, seem to be employed the most: (1) none (user has to know in advance how to initiate certain interaction, e.g. by virtual collision with hand), (2) text or 2D icons, (3) 3D icons / metaphorical objects, (4) menus, (5) context dependent object alterations (e.g. an object transforms into an interactable form when within certain distance) [2][3][7][8][9].

A work similar to ours has been reported by Regenbrecht et al. who proposed and found that illusory interactions enhance presence [21]. They have found that priming the users to expect interaction from objects can increase the sense of spatial presence, but not to involvement (i.e. higher attention) nor to realness. Their work employed user priming (to let user know to expect the possibility of interaction), finding out the cues they used to induce interaction was not obvious to the user. Our study compares different types of cues for their effectiveness in inducing interactivity and thus promoting presence.

## 3. VISUAL INFORMATION FOR INDUCING INTERACTIVITY

Leveraging on the previous work in interaction object design, we propose[1] the idea of inducing the feeling of interactivity, and thereby, increasing the level of user felt presence in virtual environments. The concept is somewhat similar to the "false affordance" that occurs when there is information that leads a user to believe there exists an affordance that is

[1] Our study started before the publication of Regenbrecht et al. in 2002.

not there [12]. Here, interactivity refers to the collective sense of identifying the target interaction object, instinctively wanting to interact with it, and intuitively knowing how to accomplish the interaction task. Note that virtual reality systems that have high degrees of interaction might have relatively low interactivity (e.g. no visual cues at all) and vice versa. Thus, we propose to use, the so called, "Visual Information for Inducing Interactivity (VII)", a collection of direct or indirect visual cues to let the user know how the objects might behave or how their behaviors might be initiated. VII can be put to good use particularly, for systems with low (actual) interaction, to increase its interactivity, and presence. Plus, VII, in general, is easy and simple (as will be illustrated in the next sections) to implement, compared to needlessly implementing a full interaction or simulation model for rarely "used" virtual objects.

We have categorized various VII's into four major types and characterized them in the following way (See Figure 1 for illustrations with a door object).

- **Explicit Description:** attaching explicit information to an object pertaining to its interactability and/or interaction methods. **Examples:** Text, Pictures, Pull-down Menus, Icons / **Characteristics:** Direct, Added to the Object, Non-realistic.
- **Context Dependent Cues/Objects:** same as explicit description except that it only appears (or disappears) when certain condition is satisfied, e.g. when the user is within certain distance of the target interaction object. **Examples:** Pop-up menus, virtual handles/buttons, metaphorical objects / **Characteristics:** Direct, Added to the Object, Non-realistic.
- **Simulation/Trace:** showing the simulated or animated results (or snapshots) of the interaction. **Examples:** Repeated self-simulation of target interaction object, Animation of initiation of interaction, Showing of one representative object state, Multiple traces / **Characteristics:** Indirect, Embedded in the Object, Realistic.

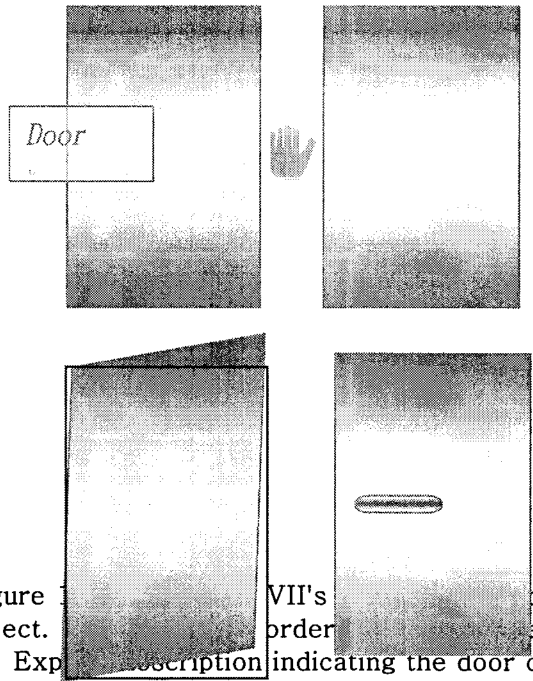


**Figure [illegible] VII's [illegible]or object. [illegible]rder[illegible]eft, (a) Exp[illegible]scription indicating the door can be opened (b) Context dependent hand indicating the door can be opened by collision with the virtual hand (c) Simulation/Trace of a half-opened door state (d) Affordance via a horizontal door handle.**

- **Affordance:** taking advantage of the actual properties of the object in a way that is easily understandable by the user to trigger one's imagination as to how the object could possibly be used (in a correct manner). **Examples:** Cup handle, Door knob, Switches and Buttons / **Characteristics:** Indirect, Embedded in the Object, Realistic.

We do not claim that this list is exhaustive, and stress that the purpose of this study is rather in verifying (Section 4) the utility of VII in promoting presence in VE. Different VII's can be used in different situations, and for different types of objects. In selecting the proper VII's, one must consider the obvious trade-off's between the naturalness (or visual realism, which is then deeply related to presence) and interaction efficiency. For instance, while the "affordance" is both a strong and a natural interaction cue, it is not always possible to design an object with rich and natural affordances. While the "Explicit Description" could clutter the virtual environment (with "signs and posts" here and there), it still gives clear messages to the user as to the environment interactivity. Context dependent cues can be confusing to the user as the user can not really tell what can be done with the object until certain condition is satisfied.

## 4. EXPERIMENT

As mentioned above, the objective of the usability experiment was to assess the effect of using various VII's in promoting interactivity and presence in a virtual environment. The experiment was conducted in two test virtual environments, both with minimal actual interaction. Subjects were questioned about the perceived interactivity, naturalness and presence in the test environments.

### 4.1 Test Environments

We built two virtual worlds as the testbed for the experiment: first was a virtual home apartment with rooms, doors, furniture, and everyday household objects (18 objects with cues out of 34). The second environment was virtual building lobby, a more formal setting in which user would feel less comfortable (compared to the first environment) about trying to interact with the environment (12 objects with cues out of 28). Figure 2 and 3 show the snap shots of the test environments.

### 4.2 Independent Variables

The objects in the two test environments were configured with three different VII's: (1) Explicit Descriptions, (2) Traces and (3) Affordances. These three were selected among the four possible types as they were hypothesized to be the two extremes and the middle in the spectrum of realism (subtleness) and task efficiency. Most importantly, these

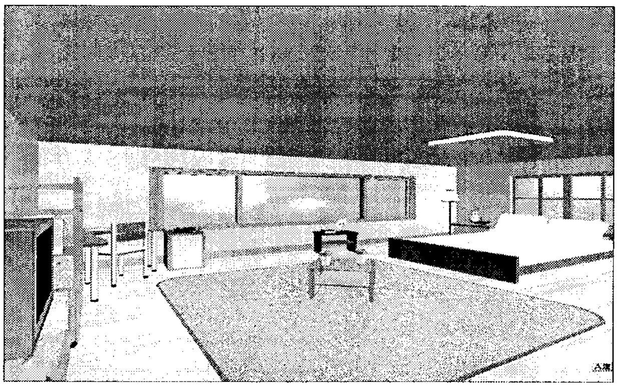

**Figure 2: The first test virtual world: home apartment.**

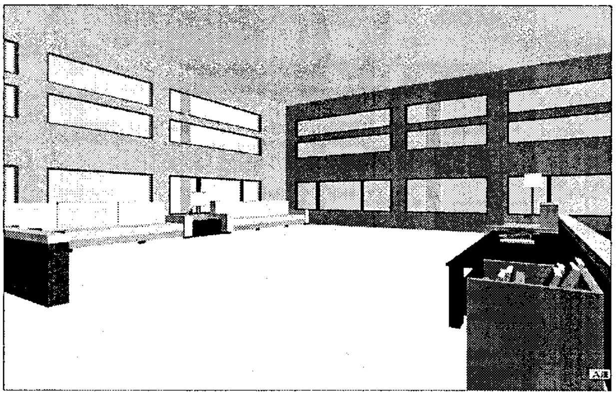

**Figure 3: The second test virtual world: building lobby.**

**Table 1: The eight usability test groups.**

| | Test Env. | Expl. Desc. | VII Type Trace | Affordance |
|---|---|---|---|---|
| 1 | Home | X | X | X |
| 2 | Home | O | X | X |
| 3 | Home | X | O | X |
| 4 | Home | X | X | O |
| 5 | Lobby | X | X | X |
| 6 | Lobby | O | X | X |
| 7 | Lobby | X | O | X |
| 8 | Lobby | X | X | O |

three types were included because they are regarded the lowest in terms of implementation cost. This latter factor would become important in actual virtual environment design (i.e. there is no sense to employing VII's for non-essential objects if their implementation is as costly as that for implementing the full simulation or interaction model). We reasoned that the "Context Dependent Cues" would normally require a simple interaction (like collision) activate the interface and, thus did not qualify for the focus of this study. Table 1 shows the summary of the independent variables and the eight test configurations. Figure 4 shows an example of an object (a lamp) used in the test environments augmented with different types of VII's.

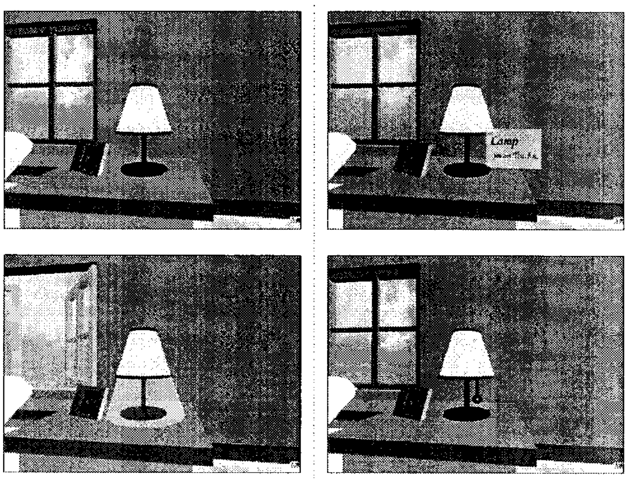

**Figure 4: A window object configured with different VII's. In a clockwise order from the top left, a lamp with (a) no VII, (b) Explicit Description, (c) Trace ("on" state), and (d) Affordance (a pull down click switch).**

### 4.3 Experimental Procedure

Subjects were first briefed about the purpose and the methods of the experiment, and, in a random order, experienced eight different test environments projected on a 50 inch screen from a fixed location (2 m from the screen). The user was asked to navigate through and view the entire test environment, and given as much time needed. The navigation was made possible through a simple hand gestures as shown in Figure 5. Prior to actually taking part in the experiment the subjects went through a short training session to get oneself familiarized with the navigation interface. After looking at each configuration, the subject was asked to fill out a questionnaire (described in the next section). After all the combinations were shown, the subjects were asked final debriefing questions. There were total of 34 subjects, all male and engineering students (both undergraduate and graduate) in the ages between 20 and 30 (average age = 24).

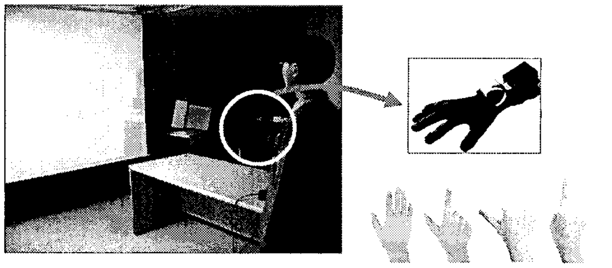


**Figure 5: A subject taking part in the experiment.**

### 4.4 Questionnaire

Besides the demographical questions, the questionnaire comprised of three small groups of questions asking to rate the virtual environments in a 7 level Likert scale: (1) perceived interactivity *(How much did you feel that you could manipulate the objects in the tested environment ?)*, (2) spatial presence *(How much did you feel as being in the environment ?)* and (3) naturalness *(Did you feel that the test environment was as natural compared to the real world ?)*. In the debriefing session at the end, subjects were asked to rank their preferences among the eight environments and how users thought the objects could be interacted with.

### 4.5 Results and Discussion

The ANOVA analysis has shown that both two test environments resulted in higher (in a statistically significant manner) interactivity, spatial presence, and naturalness, when augmented with VII's (Figures 6 to 11). In the figures, the vertical represents scores for interactivity, spatial presence and naturalness, and the horizontal represents the different styles of VII' s. The capital letters (A, B, C) represents statistically significant groupings. For example in Figure 7, use of no cues (bare) or Explicit Description produced results with no statistically significant difference.

Among the three tested VII's, the Explicit Description was the most ineffective probably due to its unrealistic nature. Sometimes, the use of Explicit Description was rated even below the default case in which no VII's were employed at all. Among the two effective VII's, the Trace was mostly rated higher in terms of perceived interactivity and spatial presence, while Affordance was better in terms of the naturalness (or realism). The overall results are also consistent with and supportive of the assumed notion of the correlation among interactivity, naturalness/realism and presence.

While the straightforward outcome, i.e. the effectiveness of VII's for interaction, is in fact just a reconfirmation of prior work (See Section 2), this also shows and confirms that such induced interactivity (without physical interaction) also promotes presence. It goes to show that it is rather the style of, not just existence of, interaction that is important factor in VE system design. For instance, one can not compare the quality of two VE's with different interaction requirements. Applying VII's is only one part (visual) of using more effective styles of interaction. Combined with actual interactions, appropriate use of VII's would improve both task efficiency and presence at the same time. It can be used to evoke presence without the full model details. Overall, not many differences have been shown between the two test environments, and this hints on the possibility of the domain generality of the proposed approach.

## 5. CONCLUSION

This paper has proposed the use of "Visual Information for inducing Interaction (VII)", a collection of direct or indirect visual cues to induce the feeling of interactivity and presence without actual physical interaction. The effectiveness of the proposed concept has been verified through usability experiments in two

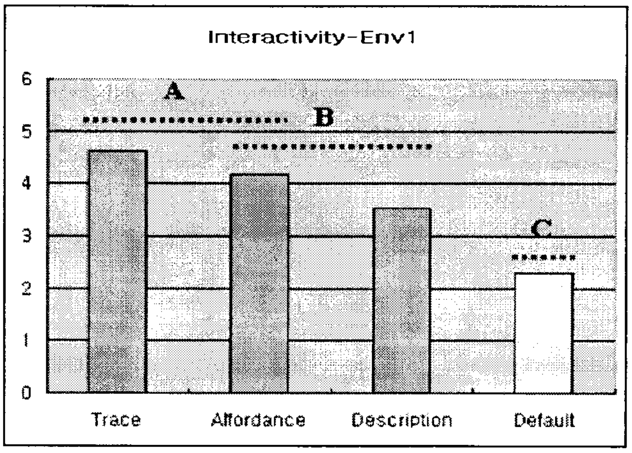


Figure 6: Perceived interactivity in test environment 1 (Home).

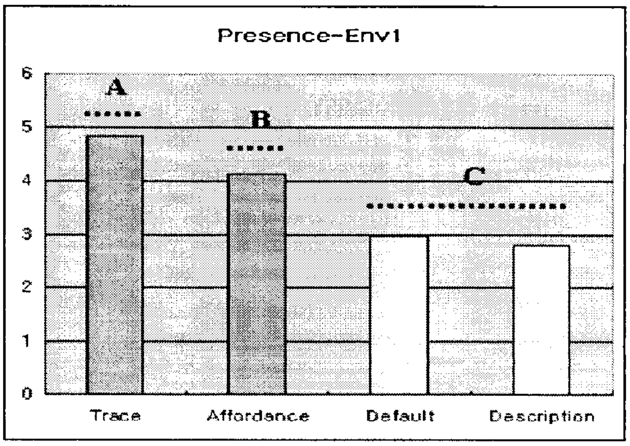


Figure 7: Perceived presence in test environment 1 (Home).

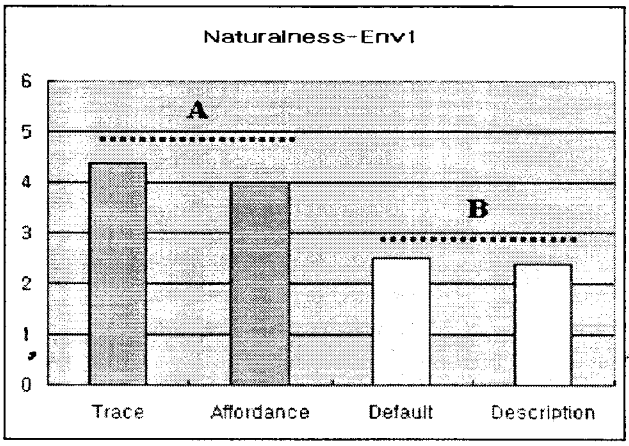


Figure 8: Perceived naturalness in test environment 1 (Home).

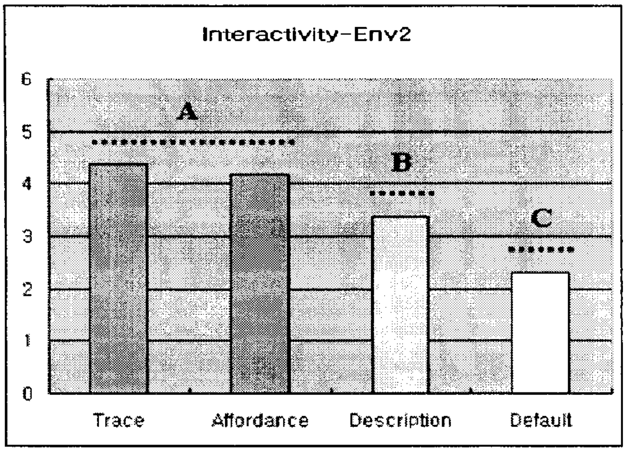


Figure 9: Perceived interactivity in test environment 2 (Lobby).

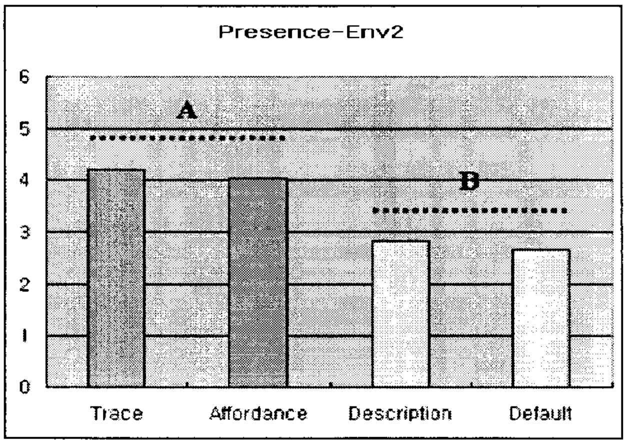


Figure 10: Perceived presence in test environment 2 (Lobby).

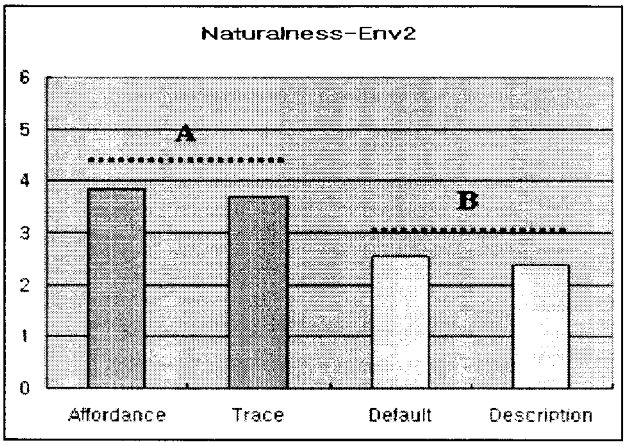


Figure 11: Perceived naturalness in test environment 2 (Lobby).

different virtual environments. Among the VII's we tested, Explicit Description was rather ineffective for promoting presence because it was an unrealistic method and it cluttered the virtual environment. It is the one of the first works to show that such induced interactivity (without physical interaction) can also promote presence in VE's and to make comparisons on different styles of promoting interactivity. As pointed out in the work of Regenbrecht [21], we acknowledge the danger that the results of the within-subject experiment (like this one) would be biased due to the possible learning effects. Yet, we take some comfort in the fact that our results are consistent with those of Regenbrecht' s between-subjects test.

VII's can be effectively applied in an economic VE design. In most cases, the number of objects that the user can or will interact with are small. Most objects are decorative or auxiliary. VII's can be applied to these objects to increase "fake" interactivity and overall presence with a small amount of extra modeling effort. In a different continued experiment, we observed that when users actually tried to use an object with induced interactivity (e.g. door with a handle that does not open), the overall presence dropped to a level that was lower than not using induced interactivity at all. Thus, we can employ a probabilistic modeling approach and use induced interactivity for objects, considering the expected presence or interactivity value (e.g. use induced interactivity for decorative objects that have very low possibility of user wanting to interact with).

## 6. ACKNOWLEDGMENTS

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