Silhouette Interactions– Using the Hand Shadow As Interaction Modality

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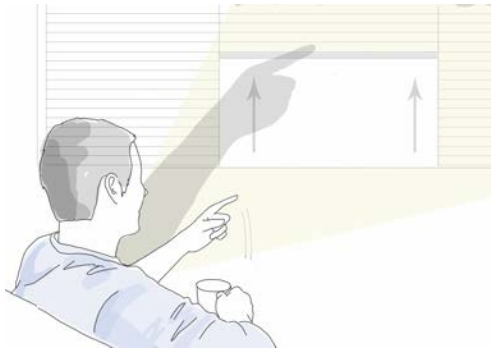

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Abstract
We present the concept of Silhouette Interactions, using the shadow of our hand as an extension of our body to interact with our physical environment. We apply Silhouette Interactions to the application case of home appliance control, show 2 user studies to identify interesting appliances, actions and shadow gestures to be used. Informed by the studies, we also implement an initial prototype system for further evaluation. We discuss best practices and lessons learned for Silhouette Interactions.

Author Keywords
Shadow Interaction; LEAP Motion; Home Appliances; Home Automation

ACM Classification Keywords
H.5.2 [User Interfaces]: Input devices and strategies.

Introduction
Our shadow is a "natural" extension to our body, it's often used for play and entertainment (e.g. shadow puppets). There is substantial work in researcher applying shadow interactions to projections (mobile and stationary projectors)[2]. To our knowledge, there are very few works that explore hand shadow manipulate real world objects. However, we believe it's an intuitive way to interact in smart environments. The hands are our most important

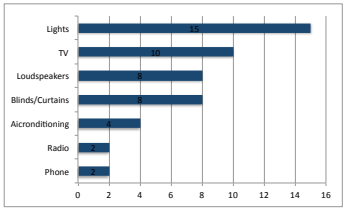

Figure 1: The user preferences

Appliances	Actions
Light	turn on/off, control brightness
TV	turn on/off, switch channels
Speakers	turn on/off, adjust volume
Blinds	move up/down, adjust angle
Fan	turn on/off, adjust intensity
Cleaning robot	turn on/off, tell where to clean

Table 1: Appliances and corresponding interactions for the experiments.

Figure 2: Initial prototype setup.

tools and the silhouette of our hands can be seen as a easy to understand extension.

This paper explores the design space of hand shadow based interactions with a focus on the home appliance scenario. We believe home appliances are the right application case, as we get more and more computer-based devices in our house and tools like a universal remote are hard to setup, not even mentioning the task to remember the functionalities of the buttons.

In this case natural gestures based on shadow projection could be the intuitive solution. Although we focus on home appliances, we believe that most findings can also be applied to other use cases.

The main contributions of this paper are (1) we present the concept of Silhouette Interactions: interacting with the physical world using your shadow as a natural extension, (2) we apply the concept to the control of home appliances, exploring in user studies the most interesting appliances, evaluating gestures and use cases.

Related Work

There is a lot of work using hand and body shadows to interact with projections or large displays[3]. We neglect the area of mobile projection as it is only faintly related and cannot be described in detail in this paper. Shoemaker et al. show how to use an adjustable spotlight to reach interact even with large size projections[6]. In contrast we use shadow projections to interact with real world objects. Some systems have a hybrid approach overlaying information on objects using projection[4]. However the hand shadow interactions envisioned are often very basic and not explored (e.g. only one finger tap or just focusing on the which part gets occluded). The closest to our work, Cowan et al. focus on exploring shadow gestures for collaboration on mobile projectors [2]. Yet, the emphasis on this work is on the group aspects and picking easy understandable gestures for a couple of people to work together.

Okahara et al. explore the psychological effect of using a projected hand as an extension to manipulate objects [5]. Also there is a lot of work on mobile hand gestures without projection [1], we see them as complementary to our research. So far we are unaware of any work that explores hand shadow gestures as a means to manipulate real world objects in particular in regard to the home automation scenario.

Concept:Silhouette Interactions

We propose to use the projected shadow of the user's hand to interact with physical, smart objects around the user extending and augmenting the user's body.

For an example in the teaser figure on the first page, a user sits on the couch and controls the blinds by projecting the shadow or silhouette of his hand on the object performing an intuitive shadow gesture to move them up.

What Devices do people want to control with shadows?

We performed structured interviews with 20 users (12 male 8 female, average age 25, std 8) focusing on Silhouette Interactions. We introduced them to the concept showing them an LED light and the shadow projection. 11 already used flash lights as a kid to play with their shadow. All 20 found the Silhouette Interactionsconcept useful and would use it during everyday life. 4 had reservations depending on the size of the device and would not want to wear a light on the top of their arm/torso all day.

15 were familiar with hand gesture recognition using Kinect and/or Leap Motion. 13 of the 15 found the shadow more

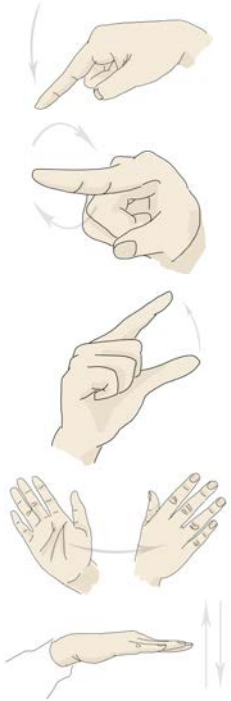

Figure 3: Sketches of the gestures derived from the user study and used in the initial prototype: tap to turn on a device, circle,pinch,swipe, move up/down and flip hand to control a device.

suitable to interact with real world objects. 5 users think the interactions are easier to remember if they see their hand shadow. We aimed the remainder of this study to get ideas on the design and promising use cases. We asked the users to explore what kind of (home) appliances they could think of controlling with shadows and in what circumstances the users wanted to control sth in sight from a distance. The interviews were conducted in different environments so that the users are not primed to certain interaction ideas (7 at office, 7 at living room, 6 at restaurant).

All users want to control lights, interestingly most of them wished to not only turn them on or off but change their brightness 1. The next appliances the users want to interact with are TV, speakers, curtains/blinds and air-conditioning/ fans. 4 users also wanted to use the radio (controlling channels and volume) as well as taking phone calls using a free-speaker. We also got several unique answers: controlling a cleaning robot, radiator, heated bathtub and washing machine. One user mentioned they want to use the shadow to get haptic feedback from devices (feel how warm/cold the radiator is etc.).

User Study: What shadow gestures to use for which interaction for which appliance?

After evaluating the best appliances and action types, we picked the most interesting use cases (shown in Table 1) for this study with the aim to find suitable shadow gestures for the given actions. 12 volunteers (5 female, mean age 26, std 7) participated.

Experimental Design and Setup

We discussed with 15 users (10 male 5 female, age 22-60) the idea of Silhouette Interactions. We introduced them to the concept showing them an LED light and the shadow projection. 12 found the Silhouette Interactionsconcept useful and would use it during everyday. 3 had reservations depending on the size of the device and would not want to wear a light on the top of their arm/torso all day. We discussed which appliances the users would want to control.

In a follow-up study with the aim to find suitable shadow gestures for a home automation scenario. 8 volunteers (3 female, age 24-36) participated.

The independent variables for our study were the appliances. We performed the study in a living room scenario. We provided a stand light, fan, speakers, TV, cleaning robot and blinds. We explained the Silhouette Interactionsconcept to the participants as given above. We equipped each participant with an LED We let them also try different places to mount the light. All users mounted it on the left/right side of the torso (depending on their handedness and preference) and we let them perform some free-form hand shadows on the wall, to get used to the shadow. Afterwards we asked them to come up with gestures to perform actions they associated with an appliance using their shadow. The order of the appliances was determined by latin square design. At the end of an experimental run, we interviewed them about how much they liked the interaction idea (positive and negative thoughts), if they could imagine using it and where they see other application areas of Silhouette Interactions. The complete user study was videotaped for later reference. One interviewer conducted the study and one observer took notes during each run.

Results and Discussion

Figures 3 and 4 give an overview over most of the gestures the study participants came up with. For the light, most users performed a tap gesture (Figure 4a) on top of the light for turning it on/off, one user swiped and one knocked on the light.

Figure 4: Sample pictures of the gestures performing actions: tap to turn on a device, circle,pinch,swipe, move up/down and flip hand to control a device.

To control brightness most users performed the up/down movement along the light(Figure 3e), one used a pinch gesture (open to close for decrease, close to open for increase), two used the circle gesture (right turn for increase, left turn for decrease). Most participants performed a tap press on the on button of the TV to turn it on/off, 2 used tap on the TV top, swipe left/right for changing channels. One turned the hand palm left right for changing. For the speakers, all participants taped the on/off switch, and used the move up/down gesture to control the volume, except 2 used who used the circle motion. To open/close the blinds, 4 users moved the hand up/down (Figure 3e) to indicate the position, 2 users taped at the position they wanted the blinds to be, 2 users swiped upwards/downwards.

For interaction with the fan, most users performed also tap for turning it off and on. Yet, the location of the tap diverged, most taped on the top again, yet 2 users tapped on the black start button. To increase and decrease the intensity all users used the circle with the index finger (right turn for increase, left turn for decrease), one user used a slow circular motion for decrease and fast motion for decreasing intensity. We implemented a prototype system based on the gestures using Leap Motion an LED and a smart phone, see Figure 2 for details.

Conclusion and Future Work

We present Silhouette Interactions, an intuitive way to interact with the physical world. From the user studies we saw that all users liked the interaction style and we could come up with a concise interaction vocabulary (shadow gestures) to use for the application case. In future work, we want to evaluate the prototype in more detail overcoming the current limitation (using the smartphone orientation for device selection and the limited distance for the gestures related to the leap motion skeleton tracking range).

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