Towards an Anthropomorphic Lamp for Affective Interaction

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Abstract
This paper presents the concept of a lamp that allows displaying and collecting user's emotional states. In particular, it displays the emotional information changing colors and facial expressions; in fact, the lamp is characterized by anthropomorphic form and behavior in order to make the interaction more natural and spontaneous. The user can interact with the lamp through tangible gestures typically used in social interactions by humans. Two different scenarios involving the use of the lamp as a companion and for computer-mediated communication are presented.

Author Keywords
Affective computing; computer mediated-communication; life-like object; tangible gestures

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
Nowadays, computer-mediated communication is becoming a focal point of our lives; in fact, some psychologists and sociologists claim that the current trend of interpersonal interaction is shifting from the physical to the virtual world [6]. A consequence of the Human-Computer-Human Interaction (HCHI) is that all

Figure 1. The ADA lamp in the happiness state.

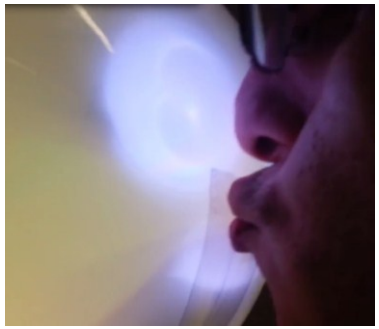

Figure 2. A user kissing the ADA lamp.

the paralanguage of a normal face-to-face communication is missing; for this reason, the computer-mediated communication of emotions is quite complicated. For instance, in instant messaging software and social networks the facial expressions and the prosody of the voice are (inadequately) replaced with emoticons and punctuation. The interpersonal touch, usually provided by contact gestures in a face-to-face interaction, is completely absent in HCHI.

We propose the concept of an anthropomorphic lamp called ADA (Anthropomorphic Display of Affection), which introduces a novel and more natural way for the communication of emotions (see Figure 1). ADA's anthropomorphic features and behavior allows for the exploration of new interaction modalities and facilitates the understanding of shared emotional states. In this paper, we present the concept of the ADA lamp with reference to related works present in the scientific literature. Then, we also show the different steps of the lamp design and development. Finally, we present two different scenarios for the interaction with the lamp: first, as a smart companion and, second, as a means for the distant communication of emotions.

Related work

The "Feather, Scent and Shaker" paper paved the way for the exploration of distant communication of emotions through tangible objects [13]. In this context, the LumiTouch frame was the first object that allowed for an active interaction with touch-gestures on the photo-frame surface and, at the same, time provided a visual feedback in the environment [5]. This form of ambient display exploited the human peripheral vision in order to provide the emotional information communicated by a distant person without interfering with the user's focal attention. The ADA lamp can be used in a similar scenario for intimate mediated interaction and physical telepresence. The benefit provided by using an interface that allows for a richer communication of emotions over a distance was demonstrated in the *cubble* project [9]. In this work, Kowalski et al. used a cube as tangible interface and compared it to a smartphone application for long-distance relationships and they demonstrated that the tangible interface enhanced the user experience and fostered a more frequent interaction leading to emotional closeness. However, Kowalski et al.'s cube did not provide an anthropomorphic affordance for the emotion communication. Moreover, coding emotions as single colors cannot be considered as a universal interface and, in fact, the *cubble* users preferred defining their personal associations between colors and affective states.

An emerging trend in affective computing is the design of life-like tangible objects. In fact, Schmitz conducted a review of the current scientific literature and presented a detailed analysis and some guidelines for the adoption of anthropomorphism and animism as paradigms for object design [12]. Life-like objects should not only have an anthropomorphic or zoomorphic form but should also present a behavior similar to a living being. Schmitz claims that such interactive life-like objects enable building a more intuitive and more durable relationship with the user. In the literature, it is possible to find some examples of zoomorphic companions for the communication of emotions; a popular example is the Nabaztag rabbit, which communicates different kinds of information with ear postures, light and sound [10]. The Hapticat is a companion that behaves like a cat [15]; a very similar

Figure 3. The five emotional states of the ADA lamp: happy, sad, trusty (eye blink) (2x), ecstasy (2x) and angry.

concept has been proposed by Philips for their iCat, which is a robot resembling a cat and able to display emotional information performing human-like facial expressions[14]. Burneleit et al. explored the possibility of making household appliances to behave like animals with the *impatient toaster;* their tests showed that users were emotionally engaged while interacting with this life-like toaster [1]. We chose to give life to a lamp and to characterize it with anthropomorphic features. Similarly to the iCat, ADA is able to mimic human facial expressions in order to communicate emotional states; at the same time, ADA changes color according to the specific emotion in order to provide information via the peripheral visual attention. Moreover, ADA recognizes contact gestures that humans usually use in inter-personal communication. For instance, it is possible to caress, hug or kiss the lamp to make it happy (see Figure 2) and to slap or shake it to make it angry. Beyond the role of companion, the ADA lamp can be used to communicate emotional states to a distant person for affective computer-mediated relationships.

Concept

The concept of the ADA lamp is the result of an interactive experience with systems for the computer-mediated communication of emotions through ambient displays. Indeed, during a live demo at the ACII 2013 conference, Caon et al. conducted an observation study on two different types of ambient displays for emotion sharing, a RGB lamp and a robotic painting [4]. Their analysis, presented in [3], highlighted the difference of emotional engagement during the interaction with the system and the amount of attention that users gave to the different forms of feedback. The robotic painting captured all the users' attention; this robotic painting, called Aphrodite, represents the Venus head from Botticelli's "the Birth of Venus" and is able to mimic human facial expressions to communicate particular emotional states. The lamp, in this work was designed to change colors according to affective information and to be placed in the users' peripheral visual attention; however, although the lamp was placed near to Aphrodite, the users completely ignored it because they were too engaged in interacting with the painting. This observation confirmed Schmitz theory about life-like objects. For this reason, we decided to design a RGB lamp conferring it anthropomorphic features. The current ADA prototype changes color and mimics facial expression to communicate emotional states. The color-emotion mapping has been based on the Plutchick's wheel of emotions [11]. The user can interact with ADA through tangible gestures [8]. The anthropomorphic aspect helps leveraging the affordance for the natural adoption of gesture for interpersonal touch that we use with other living beings. In particular, ADA can recognize the following gestures: caressing, hugging and kissing for positive valence, slapping and shaking for negative valence.

Interaction scenarios

The ADA lamp can be used in multiple contexts. In this paper, we present two particular interaction scenarios: first as a smart companion and then as interface for affective interaction in long distance relationships.

In the first scenario, the anthropomorphic lamp presents personal intelligence and behavior; it reacts to the user's gestures and tries to attract her attention showing unpredictable behaviors. The latter can create a sense of surprise that can sustain the user engagement on the long term [12]. An advanced version of the lamp could adapt its behavior to the

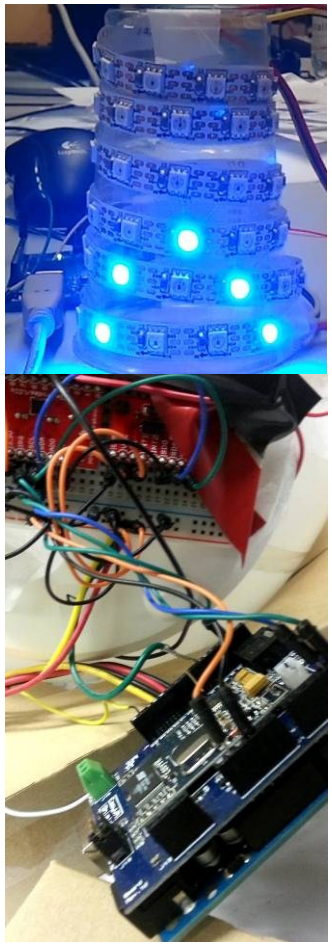

Figure 4. In the top, the cylindrical structure of the LED strip; below, the Arduino Uno with the EasyVR shield and the MPR121 and ADXL345 sensors.

current mood of the user. The companion lamp could be used just for entertainment or to share emotional states on the social networks, of course, in addition to illuminating the surrounding environment.

In the second scenario, the lamp can function as an interface for emotional telepresence and affective computer-mediated communication. In fact, ADA will represent the emotional states of a distant loved person. The emotional state can be shared via private messages on social networks or interacting directly with the lamp. The emotional state of the lamp can also change according to the gesture performed from the distant person on the other lamp: a gesture with positive valence will make the lamp to go to a positive emotional state and vice-versa. In this way, the separated people can naturally interact directly through a couple of ADA lamps without the support of other digital interfaces.

Prototype Development

The first phase of the development was focused on the realization of a lamp with an anthropomorphic form. A commercial spherical table lamp fitted perfectly the purpose of obtaining a form similar to a human head. The light bulb has been replaced with a strip with 60 RGB addressable LEDs disposed on a cylindrical structure. An internal separation with paper structures conveys the lights of specific LEDs for the left and right eyes and for a frown and a smiling mouth. LED colors and intensities are individually controlled through an Arduino Uno board (Figure 4). By selectively lighting up the different zones with different colors, it is possible to choose an arbitrary color for each face region, to hide one of the two mouths or simulate an eye blink. The five different facial expressions are shown in Figure 3.

As a second step, we implemented the recognition of gestures performed on the surface of the ADA lamp through a MPR121 capacitive sensor connected to the Arduino. Six transparent Indium Tin Oxide (ITO) electrodes have been attached all around the lamp surface and connected to the MPR121. Touch gestures such as caressing, hugging and caressing, are recognized through a simple threshold-based algorithm that check the contact on the different zones covered by the electrodes. Slapping and shaking are recognized through an ADXL345 accelerometer connected to the Arduino.

Finally, we implemented the anthropomorphic behavior of the companion lamp with a state diagram. The states in the diagram in Figure 5 represent the 5 different emotional states of the lamp, with their corresponding colors and facial expressions. Transitions to another state can be obtained by performing on the lamp a gesture, a sequence of gestures, or by a period of inactivity, i.e., absence of any gesture. In Figure 5 we show an implementation of the state diagram for the companion scenario of the lamp. In order to improve clarity, we illustrated separately the transition diagram for negative valence gestures and inactivity (on the left) and the transition diagram for positive valence gestures (on the right). Multiple arrows of the same color depict gestures that need to be performed multiple times in order to activate the transition. The transition diagram and the gesture recognition algorithms are executed in a C# application running in a PC. The ADA lamp is connected to the PC through a USB serial connection. The state diagram can be easily customized to obtain different behavior of the lamp. For example, following the examples provided by the provoking article of Buttrick et al. [2], one could

imagine that the lamp reacts in a positive manner to gesture with a negative valence and, vice versa, gets angry when the user perform gestures with positive valence. The state diagram can have input also from other stimuli, for example inferring the mood of the user from Twitter or from life-logging devices.

Future work and tests

In order to enrich the interaction modalities of the lamp, we considered the implementation of haptic feedback through a vibration motor and audio feedback through an EasyVR module. Using this module, it is also possible to implement vocal inputs, such as short phrases or vocal sounds.

Two user evaluations are planned. A first large public experience, ideally during a conference demonstration, will be focused on evaluating the reaction of the users in the short term. In particular, we would like to measure the time spent by each user observing the lamp and interacting with it, the number of different gesture discovered by each user and the total number of gesture performed for each type. The users reaction will be compared for the two examples of state diagram illustrated in the previous paragraph. The second experience will be focused on investigating the user interactions with the lamp in a longer time perspective. Also the second interaction scenario will be studied more in depth: Hemmert et al. demonstrated that it is important to carefully design devices for emotional telepresence because they can result awkward or disturbing [7]. For this reason, it is crucial to conduct further research on user acceptance and also studying potential cultural differences in the degrees of acceptance.

Description of gesture – arrow colors mapping.

Figure 5a :

- Black: shaking or slapping
- Blue: inactivity

Figure 5b :

- Yellow: caressing
- Green: hugging
- Red: kissing

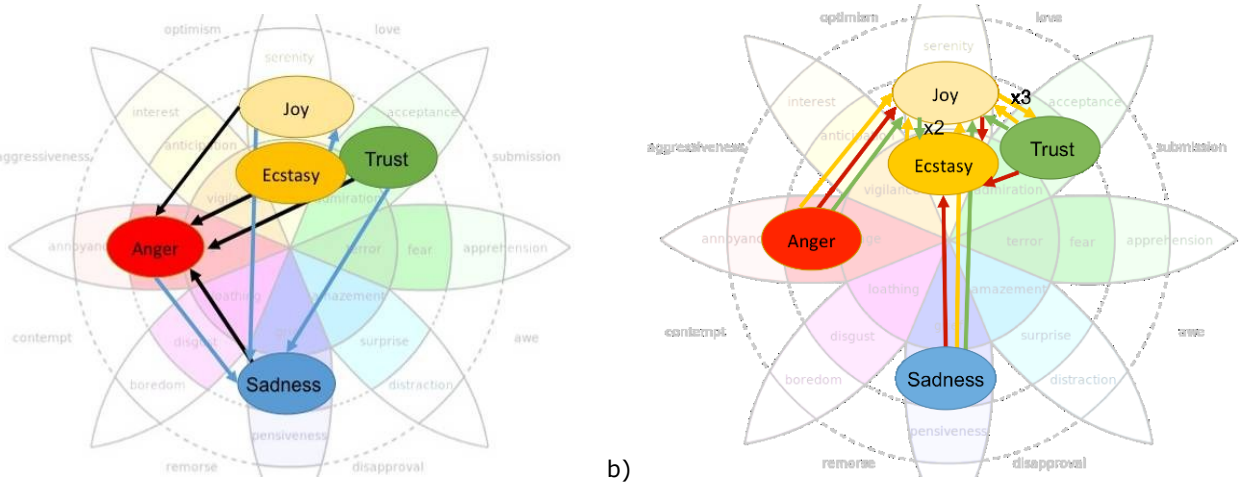

Figure 5. a) On the left, the diagram for the negative valence gestures; b) on the right, the diagram for positive valence gestures.

Conclusion

In this paper, we presented the design of an anthropomorphic lamp that is able to display emotional states through colorful facial expressions and to collect user's emotional states expressed through tangible gestures. The special anthropomorphic design is intended to facilitate the interaction with the lamp by leveraging the user ability to recognize facial expressions and to express emotional states through contact gestures that are typically performed with other humans. Two different application scenarios for the ADA lamp have been illustrated and the scenario of a companion lamp has been also implemented in a functional prototype. In this scenario, the lamp is animated through a customizable state diagram where gestures allow the transition between the different lamp internal states. Based on literature, we believe that the anthropomorphic design of the lamp could help keeping high the interest in interacting with the lamp or through the lamp. Of course, this hypothesis needs to be supported with several future user experiments. We propose to conduct one of these experiments during an interactive demonstration at the TEI conference.

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