The Ten Rules of Touch: Guidelines for Social Agents and Robots that can Touch

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Abstract

Touching is essential in interpersonal and affective communication, yet most social agents lack the capability to touch the user. In this paper we show the credibility of three premises that make the case that providing touch capability to social robots will increase their effectiveness in communicating emotions, building trust and achieving behavioral changes. The first premise is that humans can communicate distinct emotions through touch only, the second is that this is also possible through mediated (virtual) touch, and the third is that social agents can use the same mediated touch technology as effectively as humans. Based on a literature review, we also formulate ten design rules as guidance for the development of social agents that can touch. These rules concern parameters that regulate the meaning of touch cues like context and familiarity, the implicit and explicit meanings of touch, individual differences, and parameters that can be communicated through affective touch.

Keywords: avatars, emotion, guidelines, haptics, multisensory, touch, robots, social agents

1. Introduction

Social agents (avatars and robots alike) are designed to display social behavior and communicate emotions (see Figure 1 for an example). In this paper we plead for giving social agents the capability to touch users in Chapter 1 and provide ten important design rules in Chapter 2[1].

In interpersonal communication, touch is a very important channel to communicate emotions, even to the extent that the sense of touch has a distinct neurophysi-

[1] Please note that (contrary to vision and audition) touch interaction is bidirectional: users can provide information to the system (e.g. by gestures or a via a touch screen) and sense touch information displayed by the system. In this paper we focus on the later, i.e. social agents that (virtually) touch the user.

ological channel for affective touch in addition to the channels for discriminative touch [1, 2]. One could therefore argue that providing social agents with the ability to touch a user can make them more effective. Currently, the vast majority of social agents rely solely on the visual and auditory channels. However, we foresee that over the coming years social agents will increasingly use touch as affective channel, similar to the introduction of haptic displays in Human Computer Interaction (HCI) we have witnessed over the past two decades (starting with the introduction of a vibration function on mobile phones). To substantiate this prediction, we argue along the following three premises: (1): people are able to communicate affect and emotions solely by touch; (2): this interpersonal communication does not have to be direct, but can also be mediated by technology; and (3) social agents can use the same mediated technology to communicate affect.

Fig. 1. Example of a social robot that can be touched by the user, but does not have the capability to touch the user to communicate emotions.

1.1 The sense of touch in interpersonal interaction

Touching is an important form of social interaction. The importance of touch is also reflected in language: the finishing touch, rubbing people the wrong way or stroking them the right way, someone's happy, soft, or human touch, one's thick or thin skin, etc. Touch can be used to communicate distinct emotions as we will show later, but can also change behavior or attitudes. For instance, a simple touch on the arm can promote cooperation between people, make them more willing to comply with a request or provide a free ride as shown by [3, 4] (see also [5] for an excellent overview).

There is a biological principle that states that the earlier a function develops the more fundamental it is likely to be. The sense of touch is the earliest sense to develop in a human embryo [6], and is the first medium of communication between

newborns and parents (Figure 2). The critical importance of tactile communication was shown by [7]. In their experiment, infant monkeys showed a large preference for a surrogate mother consisting of wires and cloths that resembled the feel of a real mother ape over a surrogate mother consisting of wires only, even if only the latter provided food. After a thorough study of the literature, Montagu [8, p. 332] even stated that touch stimulation is a basic need which must be satisfied to survive, therewith classifying it as important as sleep, food, rest and oxygen (see also [9] for a recent review).

Fig. 2. Touching is an important form of social interaction, and is the first medium of communication between newborns and parents

Throughout the rest of our life, the sense of touch remains important in social interaction: in greetings (shaking hands, embracing, kissing, backslapping, and cheek-tweaking), in intimate communication (holding hands, cuddling, stroking, back scratching, massaging), in corrections (punishment, spank on the bottom), and of course in sexual relationships.

Important work by Hertenstein [10, 11] shows that people can communicate distinct emotions solely through touching the arm of a stranger. In a typical experiment, one participant of a dyad communicates an emotion through touching the arm of the second participant while the latter is blocked from visual and other cues. Even under these restricted touch conditions, anger, fear, disgust, love, gratitude, sympathy, happiness and sadness can be communicated above chance and with the same accuracy as facially and vocally displayed emotions.

In summary: the above data confirm our first premise that people can communicate emotions through touch.

1.2. Mediated interpersonal touch

Our second premise is that interpersonal communication can also be established through technology mediated touch or virtual touch. This is still a rather young field of research, but several concepts have been shown recently of which some are also empirically validated. For instance, [12] used the vibration function on a mobile phone to render emotional information for blind users and [13] designed a similar interface designed to convey emotional content in instant messaging. More complicated devices were developed by [14] who describe a haptic-jacket system for distant lovers' communication and remote child caring. They also enhanced second life to enable the communication of touch cues like encouraging pats and comforting hugs. A similar approach was taken by [15] and they concluded that users can not only exchange messages but also emotionally and physically feel the presence of the communication partner (see Figure 3).

Fig. 3. HaptiHug as described in [15] which enables second life users to give each other a virtual hug. This is an example of mediated human touch.

Smith and MacLean [16] performed an extensive study into the possibilities and the design space of an interpersonal haptic link and concluded that emotion can indeed be communicated through this medium. The experiments of [17] showed that even with touch cues that are extremely degraded (e.g. a handshake that is lacking grip, temperature, dryness, and texture), virtual interfaces can be effective

at transmitting emotion. Finally, [18] investigated the Midas touch effect (i.e. the effect that people are for instance more willing to comply with a request when this is accompanied with a slight touch on the arm) and compared the effect of a real touch to that of a mediated touch and concluded that both effects are in the same order of magnitude.

Although it is not clear to what extend mediated touch can replace real touch, the reports above show that it can potentially communicate affect and emotions. This supports our second premise.

1.3 Mediated touch in user-system interaction

Our third and last premise means that the touch cue is not only mediated, but produced by an electronic system instead of a human. Let us first look at the use of touching systems in general. The number of systems that include the sense of touch increased over the past decade, but they are still not very common. An important reason is the supposed low bandwidth of the touch channel. One of the first large-scale applications was the vibration function on mobile phones, communicating the 1-bit message of an incoming call. Although often underestimated, our touch sense is also able to process large amounts of abstract information. For instance, blind people who are trained in Braille reading can actually read with their fingertips. This information processing capabilities are more and more applied in our interaction with systems, and more complex information is being displayed, e.g. to reduce the risk of visual and auditory overload in car driving, to make us feel more immersed in virtual environments or to realistically train certain medical skills [19, 20], see also Figure 4, right panel.

Apart from presenting abstract or pictorial information, there are also several examples of systems that provide affective touch cues. For example, [21] developed a friction-based horizontally rotating fingertip stimulator to investigate emotional experiences and behavioural responses to haptic stimulation and show that people can rate these kind of stimuli as less or more unpleasant, arousing, avoidable, and dominating. Wang et al. [22] showed that virtual touch reinforces the meaning of a symbolic channel reducing sadness and reinforcing joviality. Finally [23] tested tactile jackets (and later blankets) to increase emotional experiences while watching movies and report quite strong effects of well-designed vibration patterns, see Figure 5.

Taken together, these studies show that also our third premise is credible: mediated touch also enables emotion communication from systems to humans.

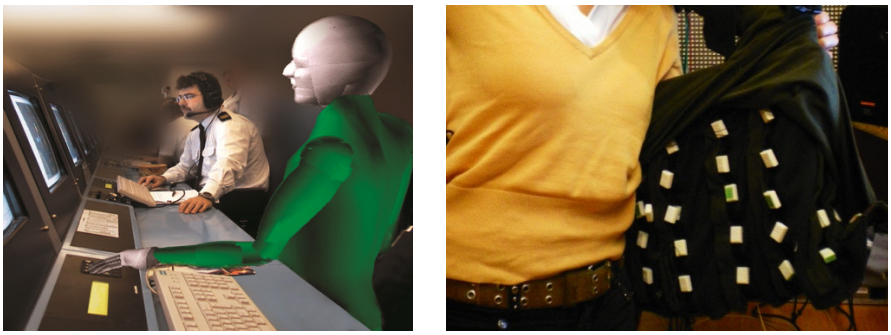

Fig. 4. Avatars lack the physical capability to touch users directly (left panel) but may use specific touch displays like simple vibration functions on mobile devices or specifically designed tactile suits or vests as depicted in the right panel.

Fig. 5. Tactile jacket by Philips® designed to increase emotional experiences when watching movies. An example of active touch generated by an interactive system and not by a human. The jacket is described in [23].

1.4 Mediated touch by social agents

In the previous sections, we tried to show that touch not only provides valuable information missing in visual and auditory information, it is especially important in affective communication. This is even more key in (social) robots and avatars than

in general HCI. Still, the interaction with social agents almost entirely relies on vision and audition with just a few exceptions. However, the physical embodiment of robots gives them a direct capability to touch users (Figure 6) and avatars may use the technology designed for other HCI applications to virtually touch their user. For instance by linking to the vibration function of a mobile device worn by the user or by specific haptic equipment as shown in Figure 4.

Fig. 6. The physical appearance of the current generation of social robots enables them to actively touch the user. But should they be allowed to? And is there a touch etiquette they should adhere to?

If we look at applications in robots and avatars, the first applications including touch facilitated information from user to system only, e.g. in the form of a touch screen or through specific touch sensors in a tangible display. Social agents that can touch the user are of much more recent date. The examples are still very few, and there has been hardly any real formal evaluation. Evers et al. [24, 25] looked at human responses to robots and found that people can experience robots that interact by touch less machine-like. Yohanan et al. [26, 27] more specifically studied the communication of emotions. They designed several haptic creatures to study a robot's communication of emotional state and concluded that participants experienced a broader range of affect when haptic renderings were applied. Participants were able to recognize the emotional renderings, but the state of arousal is communicated better than its valence. Basori et al. [28] showed the feasibility of

using vibration in combination with sound and facial expression in avatars to communicate emotion strength. Whether touch assisted in building a relationship with a social actor was the topic of studies by [29] who showed that touch (squeezes delivered through an airbladder) can improve the relation with a virtual agent and [30] who investigated the favorable effects of a humanoid robot using touch in building trust. Kotranza et al. [31, 32] describe a virtual patient as medical student's training tool that is able to be touched and to touch back. These touch enabled virtual patients were treated as social actors more than virtual patients without touch capabilities. The authors concluded that by adding haptic interaction to the virtual patient, the bandwidth of the student-virtual patient communication increases and approaches that of human-human communication. Finally, [33] created a situation in which a robot requested participants to perform a monotonous task. This request was accompanied with an active touch, a passive touch, or no touch. The result showed that the active touch increased the number of working actions and the amount of working time for the task. This confirms the earlier conclusion of [18] that the effect of the virtual Midas touch is in the same order of magnitude as the real Midas touch effect.

We foresee that there will be an increase in touching agents because this is the natural evolution we see in other HCI domains and because it helps to answer the need to develop technology that allows more intuitive, interpersonal communication. In Chapter 2 we will give ten design rules that can guide the future implementation of social agents that can touch.

2. The ten rules of touch

Rule 1. Don't hurt the user!

Before we list specific rules of touch, we urge the system designer to apply to International Standards for haptic and tactile interactions [34, 35]. Also, it is worthwhile to study general guidelines like listed in [36]. An important ground rule is of course that touch produced by the agent should never be harmful to the user in any way.

Rule 2. Touch for information processing is not the same as touch for emotion.

The majority of touch application in user-system interaction is designed for information transfer and not for the communication of emotions. Although the design for information transfer can be intuitive (e.g. see [37]), this is not a strict require-

ment as abstract or symbolic representations can also be applied (as in any other sense). This is not the case for affective communication where touch cues should be as natural and intuitive as possible and preferably mimic interpersonal touch.

As we mentioned in the introduction, a recent finding shows that the neurophysiology of affective, pleasant touch differs from that of discriminative touch. Although certainly not all affective touch applications are using this specific processing system, it means that a virtual touch that is able to tap into this affective system may result in direct and strong emotional responses. Although we have only limited knowledge yet on this affective touch system, it seems that it is closely linked to hairy (but not glabrous) skin, sensitive to strokes within a specific speed range (about 6-20 cm/s), and terminates in important emotional brain areas.

Rule 3. The meaning of touch depends on social, cultural and individual differences

There is not necessarily a universal meaning to a specific virtual touch. From interpersonal touch, we know that parameters like culture, familiarity, relationship between touchers, and gender all influences the meaning of a touch. Cranny-Francis [38] even stated that "*one of the first things people need to learn in order to live comfortably within a society or culture different from that in which they grew up is its tactile regime; the consequence of failure is not only that one is rejected as alien (connection denied) but one may also seriously offend other members.*". These consequences will also hold for social agents behaving like touch aliens and offend users. Furthermore, there may be individual differences, both in the attitude towards being touched as in perceptual abilities (for instance as function of age). The virtual touch should always be designed for and tested with the specific user population.

Rule 4. Touch has both explicit and implicit meanings

Often, the physical interaction of touch has a (symbolic) meaning in itself (such as shaking hands as confirmation of a deal). However, the same touch may also be full of emotional, intellectual and even spiritual meanings and may therefore have unwanted or unforeseen behavioral consequences. These should be carefully taken into account in the design and application.

Rule 5. The meaning of a touch depends on the context

Touch meaning also depends on the context. Don't use touch cues if the context is missing, ambiguous or wrong (see also rule 2). A tap on the shoulder may be ex-

perienced as giving comfort or as punishment depending on other (sensory) information presented by the social agent. Other cues also help to interpret a touch as incidental, or turn it into an intentional one.

Rule 6. Touch is especially good for intimate emotions

In Chapter 1, we showed that touch is good to communicate emotions. But some emotions are better communicated than others. Also, some emotions are better communicated via vision or audition. Generally, anger, fear, disgust, love, gratitude, sympathy, happiness and sadness can all be communicated, but touch seems especially well-suited for intimate emotions [39]. Again, gender and familiarity play a role, for instance, romantic couples are even able to communicate the self-focused emotions envy and pride [40].

Rule 7. Touch suits proactive agents better than reactive agents

We don't know a lot yet about the etiquette appropriate for touch interaction of social agents (or physical interaction in general). Cramer et al. [24] mention that users found touch more appropriate for proactive than for reactive agents. This matches with the observation of [41] that greater intensity of sensory and emotional responses were experienced when participants passively as opposed to actively received stimuli. This seems to indicate that people don't object to agents that use touch especially when it is in an active sense.

Rule 8. Touch can communicate multiple dimensions of emotion

Touch can not only communicate a specific emotion but also the level (or valence and arousal). Ways to communicate intensity or level include repeating the touch or increasing the strength or intensity, but more data on effective rendering of multiple dimensions is needed. (By the way, in interpersonal touch, the Midas touch effects are larger after two than after only one touch on the arm [42]).

Rule 9. Touch is also related to team performance and bonding

Social agents may also be part of a group or intended to address groups, then again another part of the touch etiquette for social agents we don't know a whole lot about is if and how touch works for groups and not only in a one-to-one situation. From interpersonal touch, we know that touching has positive effects on group performance and bonding (often seen in sports teams, e.g. [43]).

Rule 10. Touch is not always profitable

Inappropriate use of touch interaction may have null or even negative effects on the interaction [44]. But even more important is that inappropriate touch can be anxiety provoking or worse, especially for people with a touch aversion [45].

3 Summary and conclusions

Touching is an important aspect of social interaction and is critical in forming bonds, building trust, and developing personality. These are all features we expect from social agents as well. Based on the known and well-described effects of affective touch on interpersonal communication, social behavior and even well-being, we argue that giving social agents touch capabilities could be a great improvement. We showed the credibility of three premises: (1) emotions can be communicated using touch only without any other cue (2) interpersonal communication does not have to be via direct physical contact, but can also be accomplished with mediated touch and (3) mediated touch can not only be used by humans but also by systems to communicate emotions. Despite the potential of touch for social agents and the increasing application of touch interaction in other HCI domains, there are not yet a lot of social agents with touch capabilities developed let alone be formally tested. Therefore, we argue that the time is right to develop a framework and a set of guidelines for the development and application of social agents with touch capabilities. The ten rules of touch as we described (concerning amongst others parameters affecting meaning, and individual differences) are an initial step, but there is much more knowledge needed. Important topics include how to haptically render valence and arousal, how the touch etiquette for social agents looks like, which multisensory interactions are relevant, and how to incorporate social, cultural and individual differences with respect to acceptance and meaning of social agent's touch.

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