How to Touch Humans
Guidelines for Social Agents and Robots that can Touch

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Abstract—Touch is an essential channel in interpersonal and affective communication, yet most social agents currently 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, user characteristics, and parameters that can be communicated through affective touch.

Keywords—touch; robots; social agents; haptics; affect; emotion

I. INTRODUCTION

Social agents (avatars and robots alike) are designed to display social behavior and communicate emotions. In this paper we plead for giving social agents the capability to touch users and we provide ten important design rules.

In interpersonal communication, touch is a very important channel to communicate emotions, even to the extent that the sense of touch has a distinct neurophysiological channel for affective touch in addition to the channels for discriminative touch [1],[2]. We 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 for communication. However, we foresee that over the coming years social agents will increasingly use touch as affective communication channel, similar to the introduction of haptic displays in Human Computer Interaction (HCI) 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.

A. The sense of touch in interpersonal interaction

The sense of touch is the earliest sense to develop in a human embryo [3]. It is critical for our early social development [4], and throughout the rest of our life the sense of touch remains important in social interaction [5]: 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. Touch is also an effective and important non-verbal means of communication in psychotherapy [6] and nursing [7]. The importance of touch is 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.

The sense of touch can be used to communicate distinct emotions as we will discuss later, but also to elicit and modulate human emotion. Interpersonal touch therefore provides an effective means of influencing people’s social behaviors (such as modulating their tendency to comply with requests [8],[9], in affecting people’s attitudes toward specific services, in creating bonds between couples or groups, and in strengthening romantic relationships (see [10] for an excellent overview). In clinical and professional situations, interpersonal touch can increase information flow and causes people to evaluate communication partners more favorably [11]. Interpersonal touch is the most commonly used method of comforting [12]. In nursing care, human touch is an essential instrument to promote physical, emotional, social and spiritual wellbeing [13],[14],[15] (see also [5]).

In daily life we use touch to communicate our feelings with others, and to enhance the meaning of other forms of verbal and non-verbal communication. Touch amplifies the intensity of emotional displays from our face and voice [16] and can communicate distinct emotions in a robust fashion [17]. Whether a strong handshake, an encouraging pat on the back, a sensual caress, a nudge for attention, a tender kiss, or a gentle brush of the shoulder, physical contact can convey a vitality and immediacy at times more powerful than language [18]. Hertenstein [17],[19] showed 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.

B. Mediated interpersonal touch

Our second premise is that interpersonal communication can also be established through technology mediated touch or virtual touch.

Tactile or kinesthetic interfaces in principle enable haptic communication between people who are physically apart, and may provide the experiences of connection and engagement, with all the physical, emotional and intellectual feedback it supplies [20]. Several concepts have been shown recently of which some are also empirically validated. For instance, the vibration function on a mobile phone has been used to render emotional information for blind users [21] and a similar interface can convey emotional content in instant messaging [22]. More sophisticated devices like a haptic-jacket system enable distant lovers’ communication and remote child caring, and can enhance Second Life to enable the communication of touch cues like encouraging pats and comforting hugs [23]. Using these type of systems people can not only exchange messages but also emotionally and physically feel the social presence of the communication partner [24].

Smith and MacLean [25] 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. It appears that virtual interfaces can effectively transmit emotion even with touch cues that are extremely degraded (e.g. a handshake that is lacking grip, temperature, dryness, and texture: [26]). Finally, it has been shown that a mediated touch on the upper arm increases people’s altruistic behavior and willingness to comply with a request (the Midas Touch effect) to the same extent as a direct touch [27], and that haptic telecommunication affects the quality of a shared experience and increases the intimacy felt towards the other person [28].

There are also many similarities between the ways people use, experience and react to direct and mediated touch [29]. For instance, the use of mediated touch is only considered appropriate as a means of communication between people in close personal relationships [30]. The interpretation of mediated touch depends on the type of interpersonal relationship between sender and receiver [30], similar to direct touch [31],[32]. Even mediated touch communication between strangers can cause discomfort [25]. Affective tele-touch can reduce heart rate of participants that experienced a sad event [33].

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

C. Mediated touch in user-system interaction

Our third and last premise is that social agents can use the same mediated touch technology as effectively as humans. In this case 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 has 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 increasingly 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 [34].

Apart from presenting abstract or pictorial information, there are also several examples of systems that provide affective touch cues. For example, [35] developed a friction-based horizontally rotating fingertip stimulator to investigate emotional experiences and behavioral responses to haptic stimulation and showed that people can rate these kind of stimuli as less or more unpleasant, arousing, avoidable, and dominating. Wang et al. [36] showed that virtual touch reinforces the meaning of a symbolic channel reducing sadness and reinforcing joviality. Finally [37] tested tactile jackets (and later blankets) to increase emotional experiences while watching movies and reported quite strong effects of well-designed vibration patterns.

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

D. Mediated touch by social agents

In the previous sections, we argued that touch not only provides valuable information that is complementary to visual and auditory information, but is also essential in affective communication. This holds even more so for (social) robots and avatars than for general HCI. Empathic communication may serve in general to establish and improve affective relations with social agents [38], and is a fundamental requirement for social agents (whether physically embodied as robots or on-screen agents) that are designed to function as social companions and therapists [39]. However, the interaction with social agents currently still relies almost entirely on vision and audition with just a few exceptions.

The physical embodiment of robots gives them a direct capability to touch users, while avatars may use the technology designed for other HCI applications to virtually touch their user. Several devices have been proposed that enable haptic interaction with virtual characters [23],[40].
Only few studies investigated autonomous systems that touch users for affective or therapeutic purposes [41], or to communicate the affective state of artificial creatures [42].

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. [43],[44] looked at human responses to robots and found that people experience robots that interact by touch as less machine-like. Yohanan et al. [42],[45] 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. [46] 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 [47] who showed that touch (squeezes delivered through an airbladder) can improve the relation with a virtual agent and [48] who investigated the favorable effects of a humanoid robot using touch in building trust. Kotranza et al. [49],[50] 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 more like real humans than virtual patients without touch capabilities (students expressed more empathy and used touch more frequently to comfort and reassure the virtual patient). 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, [51] created a situation in which a robot requested participants to perform a repetitive monotonous task. This request was accompanied with an active touch, a passive touch, or no touch. The result showed that the active touch increased people’s motivation to continue performing the monotonous task. This confirms the earlier conclusion of [27] 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 we see the same evolution in other HCI domains and because it fulfills the need for technology that allows more intuitive, interpersonal communication. In the next section we will present ten design rules that can guide the future implementation of social agents that can touch.

II. THE TEN RULES OF TOUCH

A. 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 [52],[53]. Also, it is worthwhile to study general guidelines like listed in [54]. An important ground rule is of course that touch produced by the agent should never be harmful to the user in any way.

B. 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 [55]) this is not a strict requirement 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 [36] and preferably mimic interpersonal touch (to be effective a mediated affective touch should not create any more cognitive load than a real touch [56]).

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 [10], 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.

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

Like interpersonal touch, virtual touch does not necessarily have a universal meaning. The meaning of interpersonal touch depends on parameters like culture, familiarity, relationship between touchers, and gender. Cranney-Francis [20] 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.” This also holds for touch by social agents: if they don’t conform to the rules and expectations of the users they may be considered as offensive and will appear like aliens. Furthermore, there are also individual differences, both in the attitude towards being touched [47] as in perceptual abilities (for instance as function of age). The virtual touch should always be designed for and tested with the intended user population.

D. Rule 4: Touch has both explicit and implicit meanings

Interpersonal touch can be accidental (with no intent to communicate), instrumental (deliberate contact necessary to perform a care task), affective (to give support or show appreciation), controlling (to obtain compliance or attention), ritualistic (greeting and departure touches such as handshakes, having no personal meaning), or playful [57]. However, the same touch may either be symbolic or also be full of emotional, intellectual and even spiritual meanings and may therefore have unwanted or unforeseen behavioral consequences.
Although touch usually clearly signals the intent to communicate, its meaning is inherently ambiguous [58]. Touch by social agents may therefore become more effective when combined with disambiguating visual or auditory information. An additional benefit will be that congruent visual and auditory information enhances the perceived naturalness of mediated social touch [59],[60]. In a study by Chen et al. [41] an autonomous nurse robot touched and moved her hand along a person’s forearm. The robot either informed the participant that she was going to clean the arm (instrumental touch) or she spoke a comforting text (affective touch). The appraisal of the robot-initiated touch depended on the perceived intent: instrumental touch was perceived more favorably than affective touch, although both types of touch were positively appraised.

Hence, the design and application of virtual touch should account for its possible meaning and interpretations and avoid potential ambiguities.

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

The meaning of touch depends strongly on the context in which it is deployed [20],[61]. There is no one-to-one correspondence between meaning and touch: similar touches may have different meanings while similar meanings can lead to different touches [62]. As a result, the effects of touch applied during social interaction are also highly context dependent. For instance, in a supportive setting interpersonal touch increases altruistic behavior and willingness to comply to a request [63],[64],[65],[66],[67],[68], while it reduces helping behavior in a competitive setting [69]. In addition, the affective appraisal of touch between dyads depends on gender (same-opposite sex), familiarity (the toucher is either a stranger or familiar), their relationship (friends, competitors or unrelated), and the degree of touch receptivity of the receiver [47]. The meaning of touch can be clarified by coupling with other sensory channels [36]. However, the information in the individual sensory channels should be congruent to guarantee that the perceived gestures and resulting haptic sensations support a common interaction metaphor reflecting real touch [70].

Don’t use touch cues if the context is missing, ambiguous or wrong (see also rule 2). A tap on the shoulder may be experienced 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.

F. Rule 6: Touch is especially good for intimate emotions

In the Introduction, we showed that touch can effectively convey emotions. But some emotions are better communicated than others. Also, some emotions are better conveyed via vision or audition. Generally, anger, fear, disgust, love, gratitude, sympathy, happiness and sadness can all be communicated, but touch is the preferred nonverbal communication channel for conveying intimate emotions like love and sympathy [71]. Again, gender and familiarity play a role, for instance, romantic couples are even able to communicate the self-focused emotions envy and pride [32].

G. Rule 7: Touch suits proactive agents better than reactive agents

An appropriate etiquette for touch interaction of social agents (or physical interaction in general) has not yet been established. Cramer et al. [43] mention that users found touch more appropriate for proactive than for reactive agents. People trust a proactive robot (higher autonomy) more and a reactive robot (lower autonomy) less when it touches the user [44]. This matches with the observations that greater intensity of sensory and emotional responses are experienced when participants passively as opposed to actively receive stimuli [72], and that people attribute more credit to robots that are more autonomous and proactive [73]. Thus, it seems that people don’t object to being touched by proactive agents, especially when it is in an active sense.

H. Rule 8: Touch can communicate multiple dimensions of emotion

In addition to conveying a specific emotion touch can also communicate its level (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. (In this context it is interesting to note that, in interpersonal touch, the Midas touch effects are larger after two than after only one touch on the arm [74]).

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

Social agents may also be part of a group or intended to interact with groups. However, it is still unknown how touch should be used in interaction with groups. From interpersonal touch, we know that touching has positive effects on group performance and bonding (often seen in sports teams, e.g. [9]).

J. Rule 10: Touch is not always profitable

Inappropriate use of touch interaction may have null or even negative effects on the interaction [75]. But even more important is that inappropriate touch can provoke anxiety or worse, especially for people with a touch aversion [76].

III. 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 characteristics 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 wellbeing, 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 can also be accomplished with mediated touch and is not only restricted to direct physical contact, and (3) not only humans but also systems can use mediated touch to communicate emotions. Despite the potential of touch for social agents and the increasing application of touch...
interaction in other HCl 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 presented in this paper (concerning amongst others parameters affecting meaning, and individual characteristics) are a first step, but there is much more knowledge needed. Important topics include how to haptically render valence and arousal, how a touch etiquette for social agents should look, which multisensory interactions are relevant, and how to incorporate social, cultural and individual differences with respect to acceptance and meaning of a social agent’s touch.

REFERENCES


