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Emerging System for Affectively Charged Interpersonal Communication

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Abstract: The paper focuses on a novel system iFeel_IM! that integrates 3D virtual world Second Life, intelligent component for automatic emotion recognition from text messages, and innovative affective haptic interfaces providing additional nonverbal communication channels through simulation of emotional feedback and social touch (physical co-presence). The motivation behind our work is to enrich social interaction and emotional involvement of online interpersonal communication. iFeel_IM! users can not only exchange messages but also emotionally and physically feel the presence of the communication partner (e.g., family member, friend, or beloved person).

Keywords: Affective haptics, affective user interface, wearable devices, communication in virtual world**.**

1. INTRODUCTION

The popularity and appeal of 3D virtual worlds with embedded chat or instant messenger (e.g., Second Life, OpenSim) have made their ways around the globe. Such systems encourage people to establish or strengthen interpersonal relations, to share ideas, to gain new experiences, and to feel genuine emotions accompanying all adventures of virtual reality. Conventional mediated systems usually (1) support only simple textual cues like emoticons; (2) lack visual emotional signals such as facial expressions and gestures; (3) support only manual control of expressiveness of graphical representations of users (avatars); and (4) completely ignore such important channel of social communication as sense of touch.

Besides emotions conveyed through text, researchers developed an additional modality for communicating emotions in Instant Messenger (IM) through tactile interfaces with vibration patterns [1, 2]. However, in the proposed methods users have to memorize the vibration or pin matrix patterns and cognitively interpret the communicated emotional state. Demodulation of haptically coded emotion is not natural for human-human communication, and direct evocation of emotion cannot be achieved in such kind of systems.

Driven by the motivation to enhance social interactivity and emotionally immersive experience of real-time messaging, we pioneered in the idea of reinforcing (intensifying) own feelings and reproducing (simulating) the emotions felt by the partner through specially designed system, iFeel_IM!. The philosophy behind the iFeel_IM! (**i**ntelligent system for **Feel**ing enhancement powered by affect sensitive **I**nstant **M**essenger) is "***I feel*** [therefore] ***I am!***". The emotion elicited by physical stimulation might imbue our communication with passion and increase the emotional intimacy, ability to be close, loving, and vulnerable. The interpersonal relationships and the ability to express empathy grow strongly when people become emotionally closer through disclosing thoughts, feelings, and emotions for the sake of understanding.

2. ARCHITECTURE OF THE iFeel_IM! SYSTEM

In the iFeel_IM! system, great importance is placed on the automatic sensing of emotions conveyed through textual messages in 3D virtual world Second Life, the visualization of the detected emotions by avatars in virtual environment, enhancement of user's affective state, and reproduction of feeling of social touch (e.g., hug) by means of haptic stimulation in a real world. The architecture of the iFeel_IM! is presented in Fig. 1.

In order to communicate through iFeel_IM! system, users have to wear innovative affective haptic devices (HaptiHeart, HaptiHug, HaptiButterfly, HaptiTickler, HaptiTemper, and HaptiShiver) developed by us. As a media for communication, we employ Second Life, which allows users to flexibly create their online identities (avatars) and to play various animations (e.g., facial expressions and gestures) of avatars by typing special abbreviations in a chat window.

The control of the conversation is implemented through the Second Life object called EmoHeart (invisible in case of 'neutral' state) attached to the avatar's chest. In addition to communication with the system for textual affect sensing (Affect Analysis Model), EmoHeart is responsible for sensing symbolic cues or keywords of 'hug' communicative function conveyed by text, and for visualization (triggering related animation) of 'hugging' in Second Life. The results from the Affect Analysis Model (dominant emotion and intensity) and EmoHeart ('hug' communicative function) are stored along with chat messages in a file on local computer of each user.

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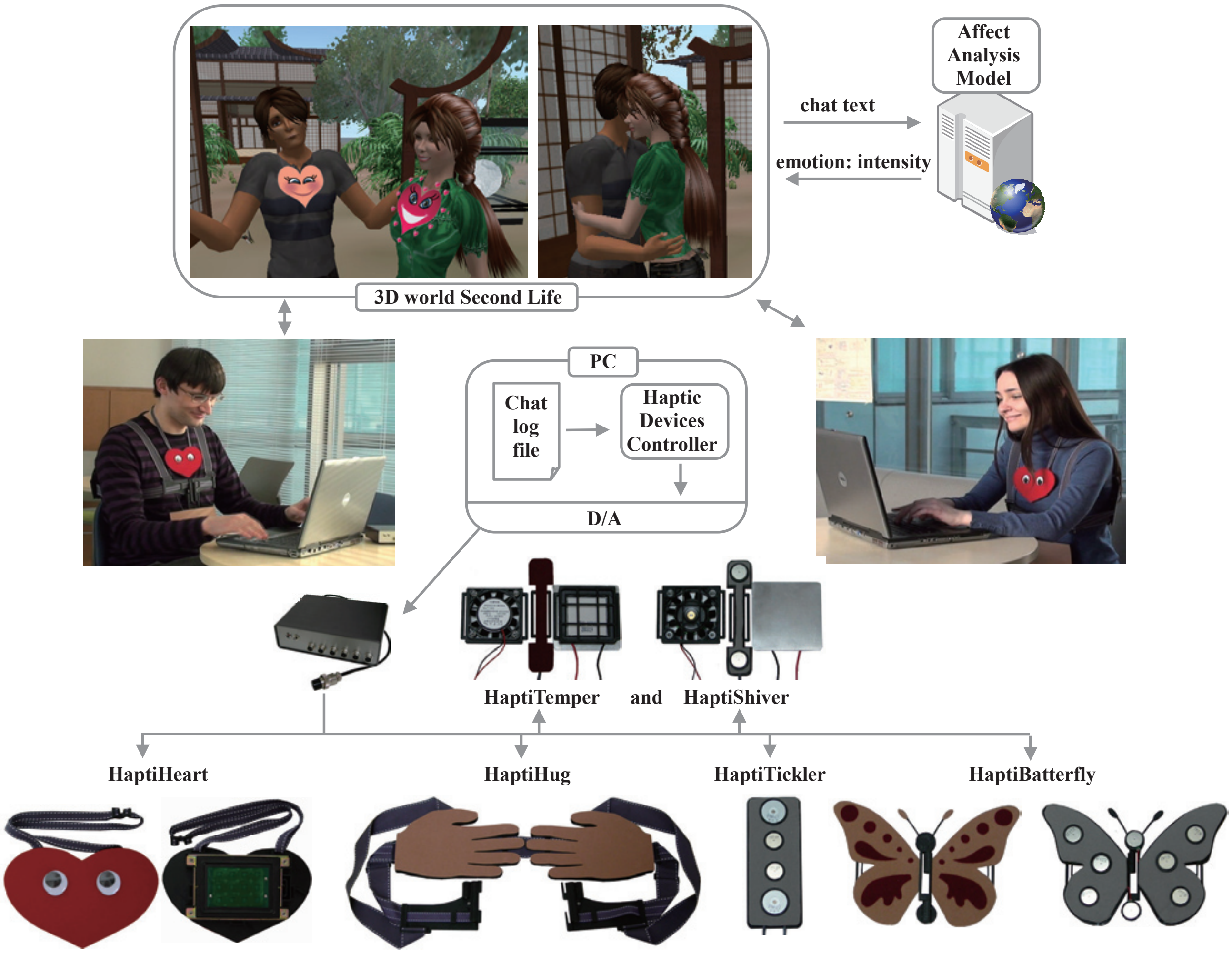

Fig. 1 Architecture of iFeel_IM! system.

Haptic Devices Controller analyses these data in a real time and generates control signals for Digital/Analog converter (D/A), which then feeds Driver Box for haptic devices with control cues. Based on the transmitted signal, the corresponding haptic device (HaptiHeart, HaptiHug, HaptiButterfly, HaptiTickler, HaptiTemper, and HaptiShiver) worn by user is activated.

3. RECOGNITION OF AFFECT FROM TEXT

The Affect Analysis Model [3] sense nine emotions conveyed through text ('anger', 'disgust', 'fear', 'guilt', 'interest', 'joy', 'sadness', 'shame', and 'surprise'). The affect recognition algorithm, which takes into account specific style and evolving language of online conversation, consists of five main stages: (1) symbolic cue analysis; (2) syntactical structure analysis; (3) word-level analysis; (4) phrase-level analysis; and (5) sentence-level analysis. Our Affect Analysis Model was designed based on the compositionality principle, according to which we determine the emotional meaning of a sentence by composing the pieces that correspond to lexical units or other linguistic constituent types governed by the rules of aggregation, propagation, domination, neutralization, and intensification, at various grammatical levels. Analyzing each sentence in sequential stages, this method is capable of processing sentences of different complexity, including simple, compound, complex (with complement and relative clauses), and complex-compound sentences. The working flow of the algorithm is presented in Fig. 2.

To measure the accuracy of the proposed emotion recognition algorithm, we extracted 700 sentences from a collection of diary-like blog posts provided by BuzzMetrics (*http://www.nielsenbuzzmetrics.com*). We focused on online diary or personal blog entries, which are typically written in a free style and are rich in emotional colourations. Three independent annotators labelled the sentences with one of nine emotions (or neutral) and a corresponding intensity value.

We developed two versions of the Affect Analysis Model (AAM) differing in syntactic parsers employed during the second stage of affect recognition algorithm: (1) AAM with commercial parser Connexor Machinese Syntax (*http://www.connexor.eu*) (AAM-CMS); (2) AAM with GNU GPL licensed Stanford Parser (*http://nlp.stanford.edu/software/lex-parser.shtml*) (AAM-SP). The performance of the AAM-CMS and AAM-SP was evaluated against two sets of sentences

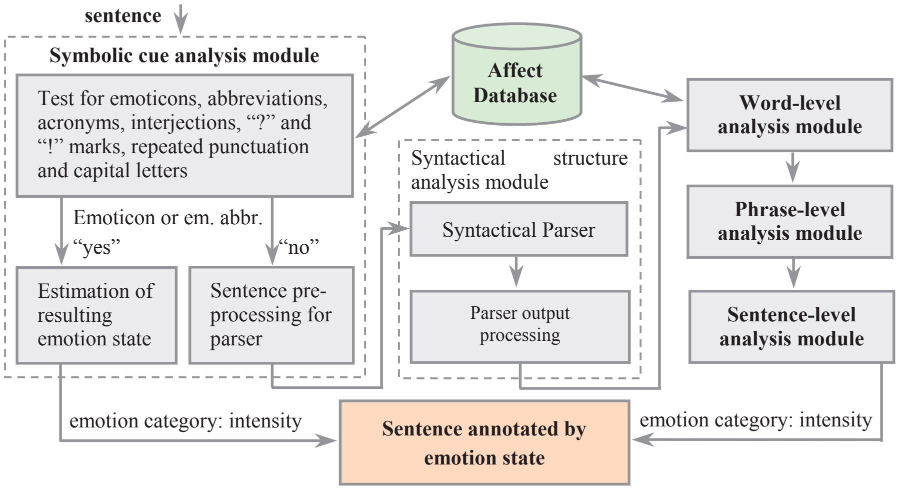

Fig. 2 Working flow of the Affect Analysis Model.

related to 'gold standards': 656 sentences, on which two or three human raters completely agreed; (2) 249 sentences, on which all three human raters completely agreed. Averaged accuracy, precision, and recall are shown in Table 1 for each emotion category. An empirical evaluation of the AAM algorithm showed promising results regarding its capability to accurately (AAM-CMS achieves accuracy in 81.5 %) classify affective information in text from an existing corpus of informal online communication.

4. EmoHeart

Once attached to the avatar in Second Life, EmoHeart object (1) listens to each message of its owner, (2) sends it to the web-based interface of the AAM, (3) receives the result (dominant emotion and intensity), and visually reflects the sensed affective state through the animation of avatar's facial expression, EmoHeart texture (indicating the type of emotion), and size of the texture (indicating the strength of emotion, namely, 'low', 'middle', or 'high'). If no emotion is detected in the text, the EmoHeart remains invisible and the avatar facial expression remains neutral. The motivation behind using the heart-shaped object as an additional channel for visualization was to represent the communicated emotions in a vivid and expressive way.

During a two month period (December 2008 – January 2009), 89 Second Life users became owners of EmoHeart, and 74 of them actually communicated using it. Text messages along with the results from AAM were stored in an EmoHeart log database. From all sentences, 20 % were categorized as emotional by the AAM and 80 % as neutral (Fig. 3). We observed that the percentage of sentences annotated by positive emotions ('joy', 'interest', 'surprise') essentially prevailed (84.6 %) over sentences annotated by negative emotions ('anger', 'disgust', 'fear', 'guilt', 'sadness', 'shame'). We believe that this dominance of positivity expressed through text is due to the nature and purpose of online communication media.

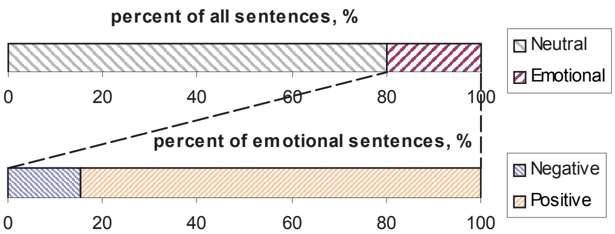

Fig. 3 Percentage distribution of sentences.

Table 1 The results of experiment with Affect Analysis Model employing different parsers.

Gold standard	Version of AAM	Measure	Fine-grained emotion categories									
			neutral	anger	disgust	fear	guilt	interest	joy	sadness	shame	surprise
2-3 annotators agreed	AAM-CMS	Accuracy	0.726									
		Precision	0.46	0.83	0.63	0.76	0.75	0.56	0.87	0.78	0.57	0.85
		Recall	0.55	0.41	0.73	0.84	0.68	0.88	0.83	0.72	0.89	0.77
	AAM-SP	Accuracy	0.649									
		Precision	0.30	0.77	0.64	0.74	0.71	0.61	0.83	0.74	0.50	0.76
		Recall	0.55	0.34	0.70	0.80	0.55	0.81	0.71	0.64	0.67	0.72
3 annotators agreed	AAM-CMS	Accuracy	0.815									
		Precision	0.26	0.92	0.83	0.91	0.83	0.44	0.95	0.88	0.67	0.86
		Recall	0.75	0.65	0.56	0.88	0.83	0.88	0.88	0.79	0.67	0.82
	AAM-SP	Accuracy	0.751									
		Precision	0.15	0.92	0.83	0.87	0.80	0.50	0.96	0.88	0.50	0.82
		Recall	0.75	0.65	0.56	0.83	0.67	0.75	0.78	0.74	0.33	0.82

We analysed the distribution of emotional sentences from EmoHeart log data according to the fine-grained emotion labels from our Affect Analysis Model (Fig. 4).

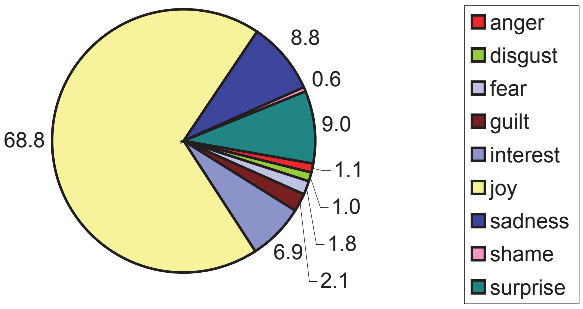

Fig. 4 Percentage distribution of sentences with fine-grained emotion annotations.

We found that the most frequent emotion conveyed through text messages is 'joy' (68.8 % of all emotional sentences), followed by 'surprise', 'sadness' and 'interest' (9.0 %, 8.8 %, and 6.9 %, respectively).

4. AFFECTIVE HAPTIC DEVICES

According to James-Lange theory [4], the conscious experience of emotion occurs after the cortex receives signals about changes in physiological state. Researchers argued that feelings are preceded by certain physiological changes. Recent empirical studies support non-cognitive theories of nature of emotions. It was proven that we can easily evoke our emotions by something as simple as changing facial expression (e.g., smile brings on a feeling of happiness) [5].

In order to support the affective communication, we implemented several novel haptic gadgets embedded in iFeel_IM!. They make up three groups. First group is intended for emotion elicitation implicitly (HaptiHeart, HaptiButterfly, HaptiTemper, and HaptiShiver), second type evokes affect in a direct way (HaptiTickler), and third one uses sense of social touch (HaptiHug) for influencing on the mood and providing some sense of physical co-presence. All these devices produce different senses of touch including kinesthetic and coetaneous channels. Kinesthetic stimulations, which are produced by forces exerted on the body, are sensed by mechanoreceptors in the tendons and muscles. This channel is highly involved in sensing stimulus produced by HaptiHug device. On the other hand, mechanoreceptors in the skin layers are responsible for the perception of cutaneous stimulation. Different types of tactile corpuscles allow us sensing thermal property of the object (HaptiTemper), pressure (HaptiHeart, HaptiHug), vibration frequency (HaptiButterfly, HaptiTickler, and HaptiShiver), and stimuli location (localization of stimulating device enables association with particular physical contact).

The affective haptic devices worn on a human body and their 3D models are presented on Fig. 5.

Fig. 5 Affective haptic devices worn on a human body.

4.1 HaptiHug: realistic hugging over distance

Among many forms of physical contact, hug is the most emotionally charged one. It conveys warmth, love, and affiliation. DiSalvo et al. [6] introduced "The Hug" interface. When person desires to communicate hug, he/she can squeeze the pillow, so that such action results in the vibration and temperature changes in the partner's device. However, this interface suffers from inability to resemble natural hug sensation and, hence, to elicit strong affective experience (only slight pressure is generated by vibration actuators); and lacks the visual representation of the partner. A simple haptic display that uses dual motors and belt for presentation of physical contact by pressing is described in [7].

The key feature of the developed HaptiHug is that it physically reproduces the hug pattern similar to that of human-human interaction. The hands for a HaptiHug are sketched from a real human and made from soft material. The couple of oppositely rotating motors are incorporated into the holder placed on the user chest area. The Soft Hands, which are aligned horizontally, contact back of the user. Once 'hug' command is received, couple of motors tense the belt, pressing thus Soft Hands and chest part of the HaptiHug in the direction of human body (Fig. 6).

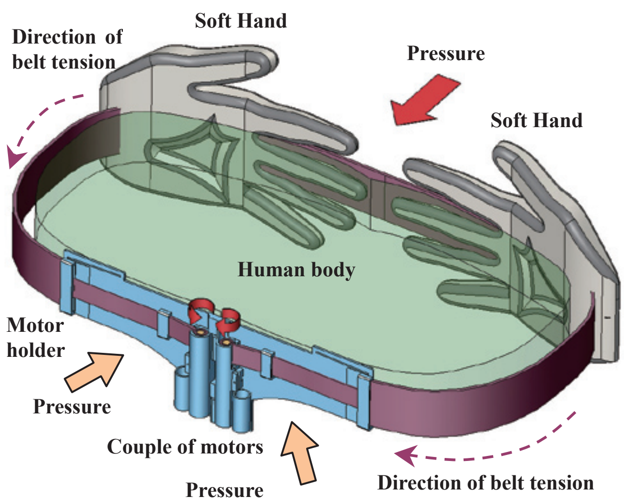

Fig. 6 Structure of wearable HaptiHug device.

The duration and intensity of the hug are controlled by the software in accordance with the emoticon or a keyword, detected from text.

4.2 HaptiHeart enhancing user emotions

We selected four distinct emotions having strong physical features: ‘anger’, ‘fear’, ‘sadness’, and ‘joy’. The precision of AAM in recognition of these emotions is considerably higher (‘anger’ – 92 %, ‘fear’ – 91 %, ‘joy’ – 95 %, ‘sadness’ – 88 %) than of other emotions.

Of the bodily organs, the heart plays a particularly important role in our emotional experience. The ability of false heart rate feedback to change our emotional state was reported in [8]. There are two major sounds that are heard in the normal heart and are often described as a lub and a dub (“lubb-dub” sound occurs in sequence with each heartbeat) [9].

We developed heart imitator HaptiHeart to produce special heartbeat patterns according to emotion to be conveyed or elicited (sadness is associated with slightly intense heartbeat, anger with quick and violent heartbeat, fear with intense heart rate). We take advantage of the fact that our heart naturally synchronizes with the heart of a person we hold or hug. Thus, the heart rate of a user is influenced by haptic perception of the beat rate of the HaptiHeart. Furthermore, false heart beat feedback can be directly interpreted as a real heart beat, so it can change the emotional perception. The 3D model of HaptiHeart is presented in Fig. 7.

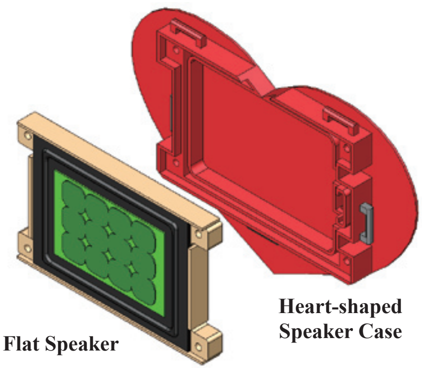

Fig. 7 HaptiHeart layout.

The pre-recorded sound signal with low frequency generates the pressure on the human chest through vibration of the speaker surface.

4.3 Butterflies in the stomach (HaptiButterfly) and shivers on body’s spine (HaptiShiver/HaptiTemper)

HaptiButterfly was developed with the aim to evocate joy emotion (see Fig. 8). The idea behind this device is to reproduce effect of “*Butterflies in the stomach*” (fluttery or tickling feeling in the stomach felt by people experiencing love) by means of the arrays of vibration motors attached to the abdomen area of a person.

We conducted the experiment aimed at investigation of the patterns of vibration motor activation that produce most pleasurable and natural sensations on the abdomen area. Based on the results, we employ ‘circular’ and ‘spiral’ vibration patterns.

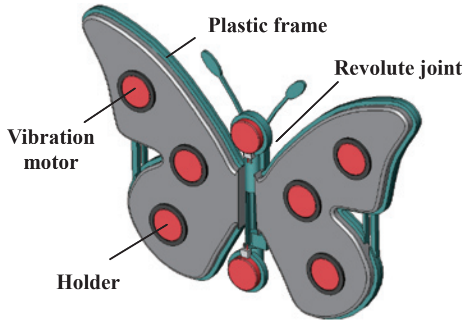

Fig. 8 Structure of HaptiButterfly.

The temperature symptoms are great indicators of differences between emotions. The empirical studies [10] showed that (1) fear and (in a lesser degree) sadness, are characterized as ‘cold’ emotions, (2) joy is the only emotion experienced as being ‘warm’, while (3) anger is ‘hot’ emotion.

In order to boost fear emotion physically, we designed HaptiShiver interface that sends “*Shivers down/up human body’s spine*” by means of a row of vibration motors (HaptiShiver), and “*Chills down/up human body’s spine*” through both cold airflow from DC fan and cold side of Peltier element (HaptiTemper). The structure of HaptiShiver/HaptiTemper device is shown in Fig. 9.

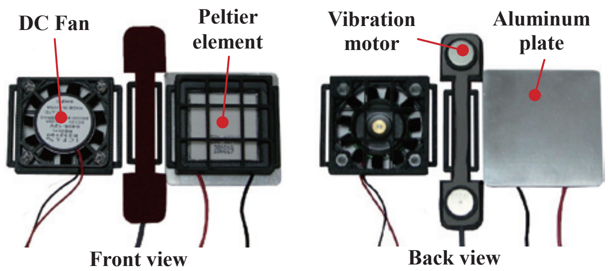

Fig. 9 Structure of HaptiShiver/HaptiTemper.

HaptiTemper is also intended for simulation of warmth on the human skin to evoke either pleasant feeling or aggression (it was proved that uncomfortably hot temperatures arouse anger feelings [11]).

4.4 HaptiTickler: device for positive emotions

Two different types of tickling are recognized. The first type is knismesis referring to feather-like (light) type of tickling. It is elicited by a light touch or by a light electrical current at almost any part of the body [12]. It should be emphasized that this type of tickling does not evoke laugh and is generally accompanied by an itching sensation that creates the desire to rub the tickled part of the body. The second type of tickle called gargalesis is evoked by a heavier touch to particular areas of the body such as armpits or ribs. Such kind of stimuli usually results in laugher and squirming. In contract to knismesis, one cannot produce gargalesis in oneself. Two explanations were suggested to explain the reasons of inability to self-tickling. The scientists supporting interpersonal explanations argue that tickling is fundamentally interpersonal experience and thus requires another person as the source of the touch [13]. On the other side of the debate is a reflex view, suggesting that tickle requires the element of unpredictability or uncontrollability. The experimental results from [14] support the later view and reveal that ticklish laugher evidently does not require that stimulation be attributed to another person. However, the social and emotional factors in ticklishness affect the tickle response greatly.

We developed HaptiTickler with the purpose to evoke positive affect (joy emotion) in a direct way by tickling the ribs of the user. The device includes four vibration motors reproducing stimuli that are similar to human finger movements during rib tickling.

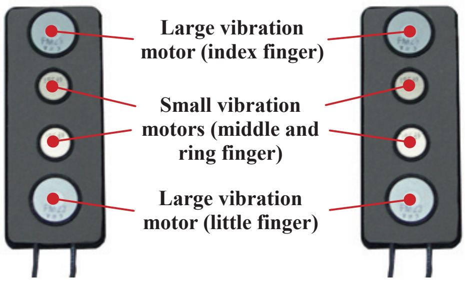

Fig. 10 HaptiTickler device.

The uniqueness of our approach is in (1) combination of the unpredictability and uncontrollability of the tickling sensation through random activation of stimuli, (2) high involvement of the social and emotional factors in the process of tickling (positively charged on-line conversation potentiates the tickle response).

5. CONCLUSIONS

While developing the iFeel_IM! system, we attempted to bridge the gap between mediated and face-to-face communications by enabling and enriching the spectrum of senses such as vision and touch along with cognition and inner personal state. In the paper we described the architecture of the iFeel_IM! and the development of novel haptic devices, such as HaptiHeart, HaptiHug, HaptiTickler, HaptiButterfly, HaptiShiver, and HaptiTemper. These devices were designed with particular emphasis on natural and realistic representation of the physical stimuli, modular expandability, and ergonomic human-friendly design.

The significance of our idea to realistically reproduce hugging is in integration of active-haptic device HaptiHug and pseudo-haptic touch simulated by hugging animation. Thus, high immersion into the physical contact of partners while hugging is achieved.

iFeel_IM! system has great potential to impact on the communication in 'sociomental' (rather than 'virtual') online environments, that facilitate contact with others and affect the nature of social life in terms of both interpersonal relationships and the character of community. Our primary goal for the future research is to conduct extensive user study on iFeel_IM! system.

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