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Toward Building Adaptive User's Psycho-Physiological Maps of Emotions using Bio-Sensors

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Abstract. We present a method applied to the emotional subjective experience of the user for extracting emotional semantic information from Autonomic Nervous System (ANS) physiological signals (skin conductance and heart rate) sensed via bio-sensors. We present a physiologically-inspired data structure based on intra-individual rule extraction used to reach an interpretation of the physiological measure closely related to the user own emotional experience.

1 Introduction

Being able to include affect sensing in Human Computer Interaction (HCI), e.g. in teaching application, Human-Robot Interaction (HRI), e.g. for assisting tele-healthcare patients remaining autonomous, and Computer Mediated Communication (CMC), e.g. mailing or artistic collaborative systems depends upon the possibility of extracting emotion without interrupting the user during HCI, HRI, or CMC. Emotion is a mind-body phenomenon accessible at different levels of observation (social, psychological, cerebral and physiological). Among these observables, physiological activity is continuous and accessible by bio-sensors coupled with computers, which makes it an interesting modality for emotional computational sensing. The field of psychophysiology of emotion establishes links between the psychological level (the conscious and subjective emotional experience of individuals) and the physiological level (the measured signals associated with emotional activity). In this paper, we follow a psychophysiological approach, and aim at designing a computing system able to extract continuously (and without interrupting the user) the conscious affective state of the user by reaching a suitable interpretation of physiological activity. We thus present how to combine the 'subjective experience' and 'physiological processor' components of the Multimodal Affective User Interface (MAUI) computing framework ([1]) to estimate the user's emotional state by introducing the subjective experience as a central guideline for emotional interpretation during HCI.

2 Proposed approach for psychophysiological emotional sensing

Previous computing approaches on emotional sensing using psychophysiology. Several affective computing systems based on psychophysiology aimed at interpreting user's physiological activity as emotional categories or affective dimensions toward near to real time recognition of emotion. Main works are those of [2],[1], [3], [4], [5]in which an emotional situation is presented to the user and physiological recordings are performed, mainly for heart rate (HR) and skin conductance (SC). The emotion associated to the situation is then retrieved from recorded physiological activity offline (or near to real-time) using statistical analysis and/or machine learning. Some of these approaches ([1],[2]) do not extract from the raw signals the features specifically related to *emotional modulation* of the ANS (and process them together with irrelevant information in terms of emotional arousal). Furthermore, many of these systems ([1],[3]) are effective and robust to perform emotion recognition at the inter-individual level (they use a common training database for different subjects) and lead to user-independent interpretations which cannot be tailored to the emotional specificity of a user nor be used to build a precise *user-model*. However, existing litterature point to the existence of psychophysiological rules or a relation between physiological signal and its psychological emotional meaning (e.g. heart rate acceleration and fear are usually positively correlated accross subjects) (see [6] for a good survey). Other approaches to emotion recognition are single-subject based and are therefore not generalizable([2]).

In an attempt to address some of these issues, we hence propose to ground our computational approach on emotional physiological findings and: (1) extract and select only emotionally-relevant features from the ANS sensed signals; (2) combine both the derived average/synthesis of known pschophysiological mappings from existing litterature and subjective modulation; and (3) design a parametric emotional model adaptable specifically to each user.

Emotionally-specific choice of features from ANS signals. Peripherally measured activity of the Autonomic Nervous System (ANS) is an indirect measure of cerebral emotional processing. Furthermore, it has been shown that ANS can discriminate affective states, both in dimensional and discrete representations [7]. This emotional information is peripherally accessible through the HR and the SC whose activity is controlled by the ANS. However, *emotional modulation* of ANS (as opposed to other modulations of the ANS) is found in phasic patterns called Skin Conductance Responses (SCRs) [8], and in the Heart Rate Variablity (HRV) in spectral domain [9]. Thus we preprocess these features to extract emotion-specific information from ANS signals.

Psycho Physiological Emotional Map (PPEM). As shown in figure 1, we propose the PPEM as a descriptive mode of representation for the psychological links to physiological features (SCRs and HRV). We define the PPEM (see equation 1, and fig. 1.1) associated to a subject i (single subject form) as a group of specific patterns (S), represented as sets of features values derived from physiological signals, and a psychological part denoted by a coordinate or a dynamic (x, y) into the dimensional affective representation valence*arousal space (which coordinates are convertible into discrete emotion , see [10]) :

$$PPEM_i = \{(x_j, y_j), S(j)\} \quad \text{with} \quad j = 1, \ldots, N \tag{1}$$

where N is the number of PPEM elements, and j the number of the element.

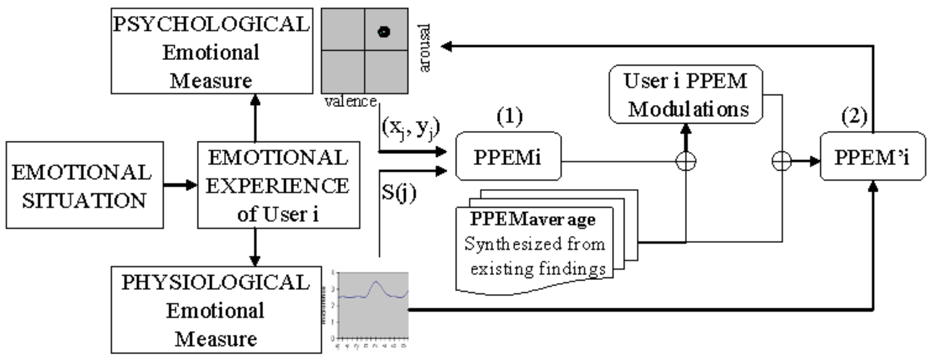

Fig. 1. Psycho Physiological Emotional Map (PPEM) construction and use.

Once created, a PPEM is used by a recognition system using the map made of elements. To be able to tailor interpretation without building a complete PPEM for each user, and taking benefits of previous approaches, we define the *parametric* form of PPEM, refered to as $PPEM'_i$ (see equation 2, and fig. 1.2). The psychological output is based on the modulation of a virtual subject PPEM, which represent the pshychophysiological links of the average population found in an experiment and/or in the literature ($PPEM_{\text{average}}$), and has similar behavior of single subject form. Inter-individual differences ($dx_{j,i}$ and $dy_{j,i}$, related to personality) are considered as subject i modulation of ($PPEM_{\text{average}}$) output, for the pairs $((x_j, y_j), S(j))$. Intra-individual differences ($dx_{j,i,c}$ and $dy_{j,i,c}$, related to mood and body state), as showed with "Day-dependance" phenomenon ([2]), are considered as subject i modulation due to specific conditions c.

$$PPEM'_i = \{((x_j + dx_{j,i} + dx_{j,i,c}, y_j + dy_{j,i} + dy_{j,i,c}), S(j))\} \tag{2}$$

Experimental set up. Our experimental set up is made of the following steps: we propose an emotional situation to the subject, and measure its emotional evaluation with both psychological method (e.g. explicit emotion expression) and physiological measures (HR and SCRs). The relations between these two types of data are analyzed to extract a semantic of physiological measure, which is used to design the $PPEM'_i$ using the $PPEM_{\text{average}}$. We continuously extract physiological parameters from the user, and try to extract in real-time his or her affective state, according to the semantic interpretation of the measures obtained with the previously assessed PPEM. We are in the process of applying this methodology to an experiment involving 40 subjects.

3 Conclusion

In this paper, we proposed a method and a system to infer psychological meanning from measured physiological cues, oriented toward near to real-time processing. We introduced the notion of Psycho Physiological Emotional Map (PPEM) as the data structure hosting the emotional mapping between psychological responses and the affective space. The PPEM approach might allow to establish a common model, taking into accounts and precisely describing both inter and intra-individual differences. Starting from an average population process, we aim at tuning the average model for each user by using the descriptive and explicit nature of the PPEM.

References

1. Lisetti, C.L., Nasoz, F.: Using noninvasive wearable computers to recognize human emotions from physiological signals. EURASIP Journal on Applied Signal Processing **11** (2004) 1672–1687
2. Picard, R., Healey, J., Vyzas, E.: Toward machine emotional intelligence, analysis of affective physiological signals. IEEE transactions on pattern analysis and machine intelligence **23**(10) (2001)
3. Kim, K.H., Bang, S.W., Kim, S.R.: Emotion recognition system using short-term monitoring of physiological signals. Medical & Biological Engineering & Computing **42** (2004)
4. Anttonen, J., Surakka, V.: Emotions and heart rate while sitting on a chair. In: CHI 2005, Portland, Oregon, USA, April 2-7. (2005) 491–499
5. Haag, A., Goronzy, S., Schaich, P., Williams, J.: Emotion recognition using biosensors: First steps towards an automatic system. LNCS **3068** (2004) 36–48
6. Peter, C., Herbon, A.: Emotion representation and physiology assignments in digital systems. Interacting with Computers **18**(2) (2006) 139–170
7. Christie, I.C., Friedman, B.H.: Autonomic specificity of discrete emotion and dimensions of affective space: a multivariate approach. Int J Psychophysiol **51**(2) (2004) 143–53
8. Bradley, M., Lang, P.: Affective reactions to acoustic stimuli. Psychophysiology **37**(2) (2000) 204–15
9. McCraty, R., Atkinson, M., Tiller, W.A., Rein, G., Watkins, A.D.: The effects of emotions on short-term power spectrum analysis of heart rate variability. The American Journal of Cardiology **76**(14) (1995) 1089–1093
10. Russell, J.A.: A circumplex model of affect. Journal of Personality and Social Psychology **39**(6) (1980) 1161–1178