Emotional Interaction (Human-Machine Confluence)

Andreas Riener
Institute for Pervasive Computing
Johannes Kepler University Linz
Altenberger Strasse 69, A-4040 Linz
+43 732 2468 8527
riener@pervasive.jku.at

ABSTRACT

The extensive propagation and usage of mobile computing devices in our everydays-life (and particulary in almost any situation) causes the opportunity for interacting with computers away from the desktop in an increasing amount [4] - with the consequence, that the role of the user and his interactions in this environment become more and more variable.

In my PhD thesis i will propose a software framework with corresponding hardware to support the interaction between human and computer in an implicit (non invasive) way by measuring and processing biological signals (the intention is to detect emotional states and react on it) with the goal of controlling computing devices by this.

Keywords

Emotional Computing, Similarity Analysis, Emotional Interaction, Human Centered Computing, Aesthetics and Computation

PROBLEM STATEMENT AND RESEARCH QUESTION

Computers need to be able to sense and interpret emotions in order to respond intelligently to (complex) human interactions. A big challenge is to unravel the "functionality" of human's emotion and to build devices that detect and reflect emotional states.

The terms affect, mood and emotion are fundamental aspects of human beeings and it is well-known that this "parameter of feelings" can influence cognition, perception, social judgement, behaviour, etc. [1]. Affect and emotion are often used as commonly understood neutral terms to represent mood, feelings, etc. in general – thus i want handle this in my work in the same way.

APPROACH AND METHODOLOGY

My approach for measuring, classification and processing of signals with a corresponding feedback to the "real-life" system is to split the process into multiple, independent stages as accounted in the next subsection.

Multi-level emotion recognition

The action of emotion processing can be divided into several autonomous stages as depicted in the figure below.

1) Biophysical sensing

Emotions in people consist of a constellation of regulatory and biasing mechanisms. Emotions can affect the voice rate, the mode of sitting, standing or walking, the type of gesturing, the kind of communicate which one another, etc.

Until now, the most explored fields of human-machine interaction are automatic facial expression and vocal inflection recognition [2].

On biochemical and pysiological sensors are e. g. conveivable: electrocardiogram (ECG), bloodgas (blood oxygen)-sensor, skin-humidity and conductance sensor, etc.

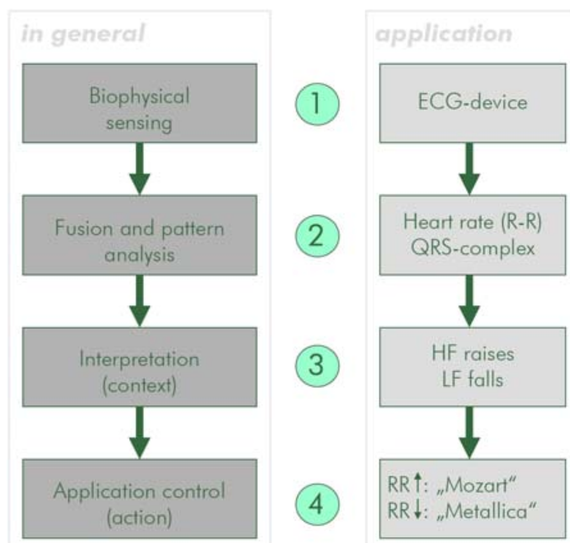

Fig. 1: Multi-level emotion recognition

2) Fusion and pattern analysis

In this stage the main functionality of the framework and the innovation is resided. (Multi) sensor values has to be evaluated, then classified based on dynamic or discriminative models and finally compared to a) other sensor values or b) data sets from a database to identify matching (emotional) patterns.

3) Interpretation of emotional states

For context constrained interpretation still frequently humans are necessary, but in the next step this should be independent performed from a computer system, e.g. by acquiring cognitive informations from a knowledge base.

4) Application control

With the result(s) from the previous stages the corresponding actions can be performed, gives a direct user feedback based on the measured sensor-values.

According to the person's interaction-interest and manner the system can get dynamic in a very high degree (known as feedback-loop).

PRELIMINARY RESULTS

Impact of music on emotional states

In [3] as well as in Fig. 2 below the impact of music on emotional states is shown. The result of this confirmed se-

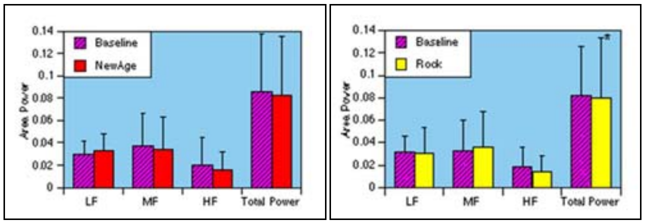

Fig. 2: Impact of Music to Heart rate variability

ries of tests should be extended, for example by performing an evaluation how different titles and/or kinds of music (classic, rock, heavy metal, etc.) affects the biological state of a human (heart frequency, heart rate variability, skin humidity, running performance, and so on).

Empiric methods in emotional computing

Working in the field of emotional computing is not limited to measuring, recording, classifying and evaluating of biological signals (e.g. the ecg-signal as shown in the figure below); until now i still have recognized that is is also necessary to do research work in the field of empiric methods to get a fundamental base for the PhD thesis (commonly electrical biosignals are measured - e.g. the heart frequency, the heart rate variability HRV, the oxygen content in the blood, the skin resistance, etc. -, processed by a computing device; finally the results are depicted as visual or audio-visual output. But this approach still needs the classification and/or interpretation of the parameters, attributes by a human!).

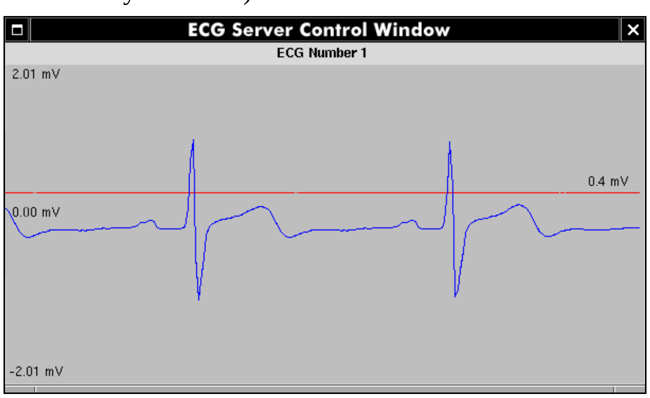

Fig. 3: ECG signal recorded from a "HeartMan" via Bluetooth

To present the technical solution alone is unsufficient, even more it is absolut required to place the PhD-thesis on an empirical base (music as modification parameter for emotional, mood states, as attribute for changing the HRV etc.).

Sensors and skills

Another important work package is a survey about (robust) "biophysical sensors" and their abilities. As the result a table consisting the various sensors with their price, degrees of freedom, accuracy, interfaces, power consumption, etc. should be presented.

CONCLUSIONS AND FUTURE STEPS

Today i am rather at the beginning of my PhD, until now i have concentrated my work in recording and processing electrocardiogram (ECG) signals and performing similarity analysis on multiple ecg-streams (for details see Fig. 4 or the project "HeartBeat", an installation in the course of the ars electronica festival 2005).

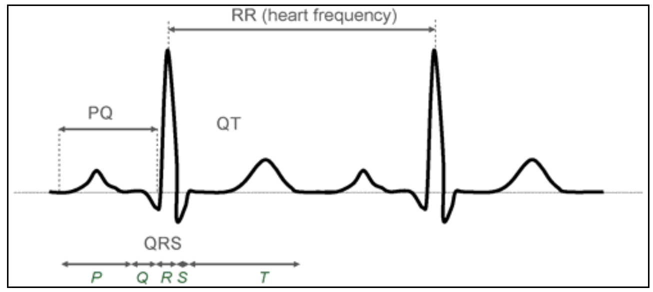

Fig. 4: ECG features used for similarity analysis in "HeartBeat"

The next steps will be an empiric evaluation of the influence of music to emotional states (as discussed in [3]), the implementing of a similarity library for supporting pattern recognition and similarity analysis in biosignals.

A joint and ongoing research project, titled "HeartMusic" deals with the thematic field "feedback (-loop) between a humans bio-logical state and a song played on a music playing device".

ACKNOWLEDGMENTS

I am grateful about the help of Prof. Alois Ferscha, my thesis advisor, for many discussions and helpful comments about the crucial points of my research work.

REFERENCES

1. James A. Russell. Core Affect and the Psychological Construction of Emotion. Psychological Review, Vol. 110, No. 1, 2003, pp. 145-172.
2. Rosalind W. Picard. Building HAL: Computers that sense, recognize, and respond to human emotion. MIT Media Lab, E15-392, 20 Ames Street, Cambridge, MA 02139, 2001.
3. Rollin McCraty, Mike Atkinson, Glen Rein, Alan D. Watkins. Music Enhances The Effect of Positive Emotional States on Salivary IgA. Stress Medicine. 1996; 12(3): 167-175.
4. Jacob O. Wobbrock. The Future of Mobile Device Research in HCI. Human-Computer Interaction Institute, School of Computer Science, Carnegie Mellon University, Pittsburgh, PA 15213 USA, 2006.
5. Hyungil Ahn, Rosalind W. Picard. Affective Cognivite Learning and Decision Making: The Role of Emotions. MIT Media Lab., Cambridge, MA 02139, USA, 2006.

EXTENDED REFERENCES

1. Himothy W. Bickmore, Rosalind W. Picard. Establishing and Maintaining Long-Term Human-Computer Relationships. Boston University School of Medicine and MIT Media Laboratory, Cambridge, (Trans. On Computer-Human Interaction, Volume 12, Issue 2 (June 2005), Pages: 293 – 327), 2004.
2. Rosalind W. Picard, Elias Vyzas and Jennifer Healey. Toward Machine Emotional Intelligence: Analysis of Affective Physiological State. IEEE Transactions Pattern Analysis and Machine Intelligence, Vol. 23, No. 10, pp. 1175 – 1191, October 2001.
3. Johan Bostrom. Emotion-sensing PCs could feel your stress. Computerworld Singapure, Vol 11, Issue 13, 22 April – 5 May 2005.
4. K.H.Kim, S.W.Bang, S.R.Kim. Emotion recognition system using short-term monitoring of physiological signals. Department of Biomedical Engineering, College of Health Science, Yonsei University, South Korea and Human-computer Interaction Laboratory, Samsung Advanced Institute of Technology, South Korea, 2004.
5. MD Dale Dubin, Rapid Interpretation of EKG's, 6th Edition, Cover Publishing Company, Tampa, Florida, USA, Feb. 2006.
6. MD J. H. O'Keefe Jr., MD S. C. Hammil, MD M. S. Freed, MD S. M. Pogwizd, The Complete Guide to ECGs. A Comprehensive Study Guide to Improve ECG Interpreatation Skills, Physicians' Press, Second Edition, Royal Oak, Michigan, 2002.
7. M. Weiser, "The Computer for the 21st Century", Scientific American, Vol. 265 No. 9, pp. 66-75, 1991.
8. A. K. Dey, "Towards a Better Understanding of Context and Context-Awareness", Thesis, Georgia Institute of Technology, pp. 4-6, 2000.
9. R. W. Picard, E. Vyzas and J. Healey, "Toward Machine Emotional Intelligence: Analysis of Affective Physiological State", Technical Report No. 536, Media Lab., MIT, Cambridge, MA, 2001.
10. N. H. Frijda and B. Mesquita, "The social roles and functions of emotions", in S. Kitayama and H. R. Markus, "Emotion and Culture," United Book Press, Baltimore, MD, USA, pp. 51-87, 1994.
11. S. Planalp, "Communicating Emotion: Social, Moral and Cultural Processes", Cambridge University Press, pp. 9-29, 1999.
12. European Opinion Research Group, "Eurobarometer - Physical Activity", Brussels, pp. 8-15, 2003.
13. C. Darwin, "The Expression of the Emotions in Man and Animals", Appleton and Company, New York, 1899.
14. P. Ekman, "Emotions Revealed, Understanding Faces and Feelings", Phoenix, 2004.
15. J. A. Russell, "A Circumplex Model of Affect", Journal of Personality and Social, Psychology, 39:6, pp. 1161-1178, American Psychological Association, 1980.
16. M. Kamadan, M. Ambe, K. Hata, E. Yamada, Y. Fujimura, "The Effect of the Emotion-related Channel in 3D Virtual Communication Environments", PsychNology Journal, Vol. 3, No. 3, pp. 312-327, 2005.
17. P. Sundström, "Exploring the Affective Loop", master thesis, Swedish Institute of Computer Science, 2005.
18. J. Gratch, S. Marsella, "Evaluating a computational model of emotion", Journal of Autonomous Agents and Multiagent Systems, issue "The best of AAMAS", 2005.
19. V. Bellotti et al., "Making Sense of Sensing Systems: Five Questions for Designers and Researchers", in Proc. CHI, Minneapolis, Minnesota, USA, 2002.
20. R. Picard and J. Klein, "Computers that Recognise and Respond to User Emotion: Theoretical and Practical Implications", Technical Report No. 538, Media Lab., MIT, Cambridge, MA, 2001.
21. K. Allmendinger, "Passung von Medium und Aufgabentyp: Der Einfluss nonverbaler Signale in desktopbasierten kollaborativen virtuellen Umgebungen", doctoral thesis, Eberhard-Karls-University, Tübingen, Germany, 2004.
22. M. Turk, "Gesture Recognition", First Draft, Microsoft Research, ch. 10, 1999.
23. T. Mori, Y. Segawa, M. Shimosaka, T. Sato, "Hierarchical Recognition of Daily Human Actions Based on Hidden Markov Models", in Proc. Sixth IEEE International Conference on Automatic Face and Gesture Recognition, 2004.

AUTHORS BIOGRAPHY

Alois Ferscha

Alois Ferscha received the Mag. degree in 1984, and a PhD in business informatics in 1990, both from the University of Vienna, Austria. From 1986 through 2000 he was with the Department of Applied Computer Science at the University of Vienna at the levels of assistant and associate professor. In 2000 he joined the University of Linz as full professor where he is now head of the department for Pervasive Computing and the speaker of the JKU Pervasive Computing Initiative. Prof. Ferscha has published on topics related to parallel and distributed computing, like e.g. Computer Aided Parallel Software Engineering, Performance Oriented Distributed/Parallel Program Development, Parallel and Distributed Discrete Event Simulation, Performance Modeling/Analysis of Parallel Systems and Parallel Visual Programming. Currently he is focussed on Pervasive Computing, Embedded Software Systems, Wireless Communication, Multiuser Cooperation, Distributed Interaction and Distributed Interactive Simulation. He has been the project leader of several national and international research projects like e.g.: Network Computing, Performance Analysis of Parallel Systems and their Workload, Parallel Simulation of Very Large Office Workflow Models, Distributed Simulation on High Performance Parallel Computer Architectures, Modelling and Analysis of Time Constrained and Hierarchical Systems, Broadband Integrated Satellite Network Traffic Evaluation and Distributed Cooperative Environments, etc. Currently he is pursuing project work related to networked embedded systems, software frameworks for context computing, coordination architectures and models, wireless and mobile ad-hoc networks and sensor/actuator networks. In his application related work he has built context based application frameworks for the JKU "Wireless Campus" network, public community displays with wireless remote controls ("WebWall"), geo-enhanced, augmented reality mobile navigation systems, RFID based realtime notification systems, wearable computing and embedded internet application frameworks ("DigitalAura", "SmartCase", "DigiScope").

He has been a visiting researcher at the Dipartimento di Informatica, Universita di Torino, Italy, at the Dipartimento di Informatica, Universita di Genoa, Italy, at the Computer Science Department, University of Maryland at College Park, College Park, Maryland, and at the Department of Computer and Information Sciences, University of Oregon, Eugene, Oregon, U.S.A. He has served on the committees of several conferences like PERVASIVE, UMBICOMP, WWW, PADS, DIS-RT, SIGMETRICS, MASCOTS, TOOLS, PNPM, ICS, etc. Prof. Ferscha is member of the OCG, GI, ACM, IEEE and holds the Heinz-Zemanek Award for distinguished contributions in computer science.

Andreas Riener

Andreas Riener is a PhD student at the Department for Pervasive Computing at the Johannes Kepler University Linz, Austria. His research interests include pervasive and ubiquitous computing, context awareness, emotional computing and sensing/analysis on biological data.

He received a Dipl.-Ing. degree in 2001 in computer science and has been working as a researcher for the Department since 2005, where he was involved in external projects with SIEMENS AG (Germany) in the field of peer-to-peer computing. Andreas Riener is a member of the Austrian Computur Society (OCG).

Timeline for the completion of the PhD thesis research is scheduled by autumn, 2007.