

# AmE Framework: a Model for Emotion-aware Ambient Intelligence

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**Abstract.** The objective of this paper is to explore human emotional intelligence and to advance research on emotion-aware technology by merging fundamental emotion theories, emotion-aware human-computer interaction, and ambient intelligence. The final goal is to facilitate building applications that take their user's emotions into account. The significance of this research stems from its potential to improve people's quality of life. Our hypotheses are that emotion-aware applications offer better user experience than the applications that ignore emotions and that emotion-aware applications and services can help users to improve their emotional intelligence, that is, skills to perceive, assess, and manage the emotions of one's self and of others.

## 1. Introduction

Information and communication technology (ICT) permeates our modern society and has a strong effect on human life. Since the beginning of the 1990's, researchers have had the vision that ICT could do much more. ICT could disappear into the environment and into small wearable devices. This invisible technology could offer useful services that support everyday activities whenever and wherever the user needs them – and it would offer the services in a user-friendly way, unobtrusively and in a natural fashion. This vision has several names and definitions that closely resemble each other; it can be called ubiquitous computing, pervasive computing, or ambient intelligence (AmI) [1, 2]. However, human emotions are rarely included in these visions and the majority of the research in this field ignores human emotions<sup>1</sup>.

Meanwhile, increased mobility, global commerce, extending community unions, terrorism, the breakdown of national safety, continual regional wars, youth violence,

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<sup>1</sup> Recently computer scientists have started to pay more attention to emotion computing, but the field is still at its infancy. Furthermore, the majority of the current studies focus on computers' emotional intelligence, whereas our research focuses on helping users to improve their emotional intelligence. The related work is discussed in more detail later in this paper.

conflicts between religions, the fragmentation of family, will mean that we feel a need to take responsibility for our mental wealth. Whether is IT capable of improving human mental wealth as it did on material wealth? Or how can we model our mental world into computer?

Concerning with the ICT advancement and the growing social issues, we suggest that the technology serving a user should take the user's emotions into account. Our hypotheses are that emotion-aware applications offer better user experience than the applications that ignore emotions and that emotion-aware applications can help users to improve their emotional intelligence. The main goal of this research is to create a framework for emotion-aware ambient intelligence (AmE). This framework facilitates building applications that participate in the emotion interaction. Such an application detects the user's emotions from sensor data. It acquires the user's motivation (identifies the intention of the emotion), and reasons a proper service that matches the user's emotions and other context. The services help the user to perform her/his everyday activities, but also produce emotional responses that have a positive effect on the user's emotions. The services can also train the user to perceive, assess, and manage her/his and others' emotions, that is, to mediate her/his emotional intelligence (i.e., skills to perceive, assess, and manage the emotions of one's self and of others). In what follows, basic concepts for emotion-aware ambient intelligence will be specified in section 2. Section 3 presents previous research about emotion cognition in social science and emotion-oriented computing in computer science, and distinguishes those studies and our research. Section 4 illustrates AmE, a framework for emotion-aware ambient intelligence. Section 5 presents the overall structure of emotion in English conversation. Conclusion and further work are given in section 6.

## 2. Definitions

*Emotion context* contains information about personal knowledge, cultural background, legacy emotion positions, present human communication, etc. It is also referred to as emotion situation that produces emotions.

*Emotion channels* are emotion carriers for understanding and expressing emotions, e.g. facial cues, vocal cues, physiological cues, gestures and body movements, actions cues, etc. All emotion capabilities of self-awareness, self management, social awareness, and social skill are fulfilled in an emotion experience.

*Emotion services* provide information responding to emotion generation. For example, a child generates happiness when her mother praises her drawing. The action of praise on a child's drawing is an emotion service.

*Emotion-aware AmI (AmE)* is a kind of AmI environment facilitating human emotion experiences by providing people with proper emotion services instantly [3].

*Ambient Intelligence (AmI)* [1, 2], is a smart environment composed of almost invisible, connected, intelligent and interactive systems, which is most naturally sensitive and responsive to the presence of people, providing information, communication services and entertainment wherever they are.

### 3. Related studies

Emotion theory studies in the social sciences form the basis on emotion classification and emotion generation mechanisms crossing multiple disciplines. Emotion computing technology is still at its infancy. Current studies focus on perceiving a person's state of mind and expressing emotions. AmI technology puts the emphasis on empowering users in pervasive information access and exchange by unobtrusive devices and distributed networks. Table 1 classifies the related research and the following text presents some related work in more detail.

*Emotion study in social science.* The scientific study of emotions dates back to the late 1800's. The earliest and most widely recognized was Darwin's work [4]. He emphasized the nonverbal rather than the verbal aspects of emotional expression. In Freudian psychoanalytic treatment, emotions are viewed as underlying forces, drives, that directly influence behaviour [5]. William James perceives emotions as bodily changes [6]. Anthropological work has challenged the Darwinian view of emotions as 'natural' in humans by claiming they are dependent on sociocultural facts [7, 8]. In the cognitive perspective, emotions require thought, and each individual's perception of an event leads to an appraisal, which in turn leads to an emotion [9]. Within sociology, many of our human emotions are seen as "results from real, anticipated, imagined, or recollected outcomes of social relations" [7]. The social constructionists view emotions as emergent in social interaction rather than as a result of evolution, biology, and individual characteristics, as serving social functions, and as culturally determined rather than biologically fixed [10].

*AmI projects.* The Oxygen project aims at human-centered communication and computing through a combination of perceptual interaction, individualized knowledge access, software agents, and collaboration technologies [11]. The Ambience project focuses on networked context-aware environments [12]. The goal of the Ozone project [13] is to investigate, define, and implement a generic framework to enable consumer-oriented ambient intelligence applications. DLNA [14] aims to create a wireless inter-operable network of personal computers, consumer electronics and mobile devices in the home enabling a seamless environment for sharing and growing new digital media and content services. Other well known projects include Gaia [15], One.world [16], and Aura [17].

*Affective computing.* Although affective computing (emotion-aware human-computer interaction) is increasingly accepted by computer scientists, the field remains relatively unexplored territory. The MIT affective computing team [18, 19] studies affective computing broadly, including indirect assessment of frustration, stress, and mood through natural interaction and conversation, emotionally intelligent computers, and technologies for improving the self-awareness of the affective state and its selective communication to others. The HUMAINE project [20] aims to lay the foundations for emotion-oriented systems that can register, model and influence human emotional and emotion-related states and processes. The NECA project [21] aims to develop a new, more sophisticated generation of conversational agents: on-line beings which are able to speak and act like humans. The ERMIS (Emotionally Rich Man-machine Intelligent System) prototype system can interpret its users' attitude or emotional state, such as interest, boredom, and anger, in terms of their speech and their facial gestures and expressions [22]. The SAFIRA (Supporting

Affective Interactions for Real-time Applications) project focuses on technology to support affective interactions, in particular on implementing a toolkit for affective computing [23].

**Table 1.** Research related to AmE

Emotion theory in social sciences	Biology	Emotions as biological responses within the individual
	Psychology	Emotions as underlying forces, drives and bodily changes
	Anthropology	Emotions are dependent on sociocultural facts
	Cognitive perspective	Emotions as the result of how we perceive and appraise a situation
	Sociology	Emotions as results from real, anticipated or imagined outcomes of social relations
	Social constructionism	Emotions as products of culture
AmI projects	Oxygen Ambience Ozone DLNA	Human-centred HCI People's presence-awareness Consumer-oriented ambient intelligence Enjoy your music, photos and videos, anywhere & anytime
Affective computing projects	HUMAINE NECA ERMIS	Future Human-Machine interfaces Animated characters Improving computers' emotional intelligence

#### 4. AmE framework

Our preliminary AmE framework is illustrated in Figure 1. This framework integrates ambient intelligence, affective computing, service-oriented computing, emotion-aware services, emotion ontology, and service ontology. It provides an open environment for developing applications that offer emotion-aware services. The framework contains a reference software architecture for emotion-aware applications and ontologies for emotions and emotion-aware services. The ontologies allow one to represent emotion knowledge about emotion types, emotion actions, emotion responses, application domains, and the relationships between them. The ontologies can also be used in semantic-based emotional intelligence testing, training, and academic research.

Emotion modelling is responsible for emotion detection and emotion motivation acquisition. Emotion detection component detects positive and negative emotions that are represented by emotion actions through face, speech, and body behaviour. Motivation acquisition identifies the intention of the emotion. Motivation identification can also be accomplished and proofed by emotion communication.

Emotion-aware service modelling is responsible for meeting the identified emotion motivations by creating services, delivering services, and managing the delivered services. The service creation includes emotion-aware service composition and emotion-aware service development. Composition refers to assembling existing

services. Service development refers to creating new services responding to identified emotion motivation. Service delivery is responsible for supplying appropriate emotion services to the users.

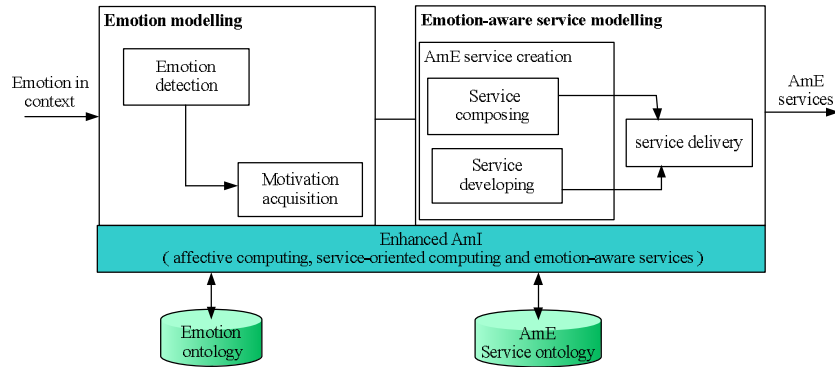


Figure 1. The AmE framework.

## 5. Structure of emotion in English conversation

Studies on emotion recognition in computer science can be roughly fallen into face-based recognition and non-face-based recognition. Face-based recognition concentrates on recognizing emotion from facial expressions by image analysis and understanding [24, 25]. Non-face-based recognition extends recognition of emotions by modeling and recognition of human behaviors such as hand gestures [26, 27], body movement [28, 29] and speech [30-36]

The processing of emotion in English conversation has not been systematically explored. Conversation is a major channel for communicating emotion. Extracting the emotion information in conversation enables computer systems to detect emotions and capture emotional intention more accurately so as to mediate human emotions by providing instant and proper services. For exploring structure of emotion in English conversation, we start with studying four linguistic features in English conversation such as lexical choice, syntactic form, prosody and sequential positioning. These four facets have been studied in conversation analysis [37-40] as Table 2.

Table 2. Structure of emotion in English conversation

Linguistic feature	Description	Emotion cues
lexical choice	The use of emotion lexical terms can be associated with emotion types in conversation.	e.g., dislike, like, pleased, displeased, joy, distress.
Syntactic form	Word order variation can be associated with the display of a speaker's emotions.	e.g., word order or question design
Prosody	Prosody interacts with the verbal components with respect to a speaker's emotions.	e.g., intonation, duration, and intensity.
Sequential positioning	The expression of an emotion is an interactional phenomenon that is associated with the organization of turns and sequences.	e.g., repeat, repair, contingency, overlap

## 6. Conclusion and future work

Human internal innate emotion intelligence could be properly mediated by integrating advanced ICT and ambient intelligence. That vision is coined as the concept of emotion-aware ambient intelligence (AmE) in this paper. To approach the vision of AmE, basic concepts related to emotion-aware ambient intelligence are defined first. Then, we survey previous research about emotion cognition and emotion-oriented computing. Finally we illustrate our preliminary work on AmE, the framework for emotion-aware ambient intelligence and present the overall structure of emotion in English conversation. The future work include: 1) further study on the feasibility and applicability of mediating human emotional intelligence by providing ambient services; 2) study on emotion structure in English conversation for detecting emotions and identifying emotion motivations. 3) study on emotion services modelling for a pervasive emotion-aware service provision responding to emotion motivations. 4) implement the AmE framework and developing application prototypes.

## References

1. K. Ducatel, M. Bogdanowicz, F. Scapolo, J. Leijten, and J.-C. Burgelman, "SCENARIOS FOR AMBIENT INTELLIGENCE IN 2010," ISTAG 2001.
2. B. Twan, G. Marc, and D. Groot, "Ambient intelligence: impact on embedded system design," Kluwer Academic Publishers, 2004.
3. J. Zhou and P. Kallio, "Ambient Emotion Intelligence: from Business-Awareness to Emotion-Awareness," Proceeding of 17th International Conference on Systems Research, Informatics and Cybernetics, Baden-Baden, Germany, 2005.
4. C. Darwin, *The Expression of Emotion in Man and Animals*: Indy Publish, 1872.
5. S. Freud, *Beyond the Pleasure Principle*: New York: Norton, 1975.
6. W. James, "Psychological essay: What is an Emotion?," *Mind*, vol. 9, pp. 188-205, 1884.
7. M. Lweis and J. M. Haviland, "Handbook of Emotion." New York: The Guilford Press, 1993.
8. C. Lutz, *Unnatural Emotions: everyday sentiments on a micronesia atoll and their challenge to western theory*. Chicago: University of Chicago Press, 1988.
9. R. Cornelius, *The Science of Emotions*: Upper Saddle River, NJ: Prentice-Hall, 1996.
10. R. Plutchik and H. Kellerman, "Emotion: Theory, Research and Experience," vol. 1. New York: Academic Press, 1980.
11. "Project Oxygen," <http://www.oxygen.lcs.mit.edu/>, 2004. 22 July, 2007.
12. ITEA-AMBIENCE, "Context-Aware Environments for Ambient Services," [www.itea-office.org/public/project\\_leaflets/AMBIENCE\\_results\\_oct-04.pdf](http://www.itea-office.org/public/project_leaflets/AMBIENCE_results_oct-04.pdf), 2004.
13. IST-Ozone, "OZONE: New Technologies and Services for Emerging Nomadic Societies," <http://www.hitech-projects.com/euprojects/ozone/>, 2004. 22 July, 2007
14. DLNA, "DLNA: Enjoy your music, photos and videos, anywhere anytime," <http://www.dlna.org/en/consumer/home>, 2006. 22 July, 2007
15. M. Roman, C. Hess, R. Cerquiera, A. Ranganathan, R. H. Campbell, and K. Nahrstedt, "A Middleware Infrastructure for Active Spaces," *IEEE Pervasive Computing*, vol. 1, pp. 74-83, 2002.
16. R. Grimm, "One.world: Experiences with a Pervasive Computing Architecture," *IEEE Pervasive Computing*, vol. 3, pp. 22-30, 2004.
17. D. Garlan, D. P. Siewiorek, A. Smailagic, and P. Steenkiste, "Project Aura: Toward Distraction-Free Pervasive Computing," *IEEE Pervasive Computing*, vol. 1, pp. 22-31, 2002.
18. "Affective computing," 2006. "<http://affect.media.mit.edu/>, 2006. 22 July, 2007.

19. R. W. Picard, *Affective computing*: MIT Press, 1997.
20. "Human-Machine Interaction Network on Emotion," HUMAINE project, 2004. <http://emotion-research.net/>, 22 July, 2007.
21. J. Salvachua, Huecas, G., Rodriguez, B. and Quemada J., "Modelling a distributed multimedia conference with rdf," Proceeding of the International Semantic Web Conference, Sardinia, Italia, 2002.
22. "Emotionally Rich Man-machine Intelligent System," <http://www.image.ntua.gr/ermis/>, 22 July, 2007.
23. SAFIRA, "Supporting Affective Interactions for Real-time Applications (SAFIRA)," <http://www.sics.se/safira/index.html>, 2002. 22 July, 2007.
24. J. M. Susskinda, G. Littlewort, M. S. Bartlett, J. Movellan, and A. K. Anderson, "Human and computer recognition of facial expressions of emotion," *Neuropsychologia*, vol. 45, pp. 152-162, 2007.
25. P. J. Phillips, P. J. Flynn, T. Scruggs, K. W. Bowyer, J. Chang, K. Hoffman, J. Marques, M. Jaesik, and W. Worek, "Overview of the face recognition grand challenge," proceeding of IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2005.
26. T. S. Huang and V. I. Pavlovic, "Hand gesture modeling, analysis, and synthesis," proceeding of International Workshop on Automatic Face- and Gesture- Recognition, 1995.
27. X. Yin and M. Xie, "Hand gesture segmentation, recognition and application," proceeding of IEEE International Symposium on Computational Intelligence in Robotics and Automation, 2001.
28. D. M. Gavrila and L. S. Davis, "Towards 3-D model-based tracking and recognition of human movement: a multi-view approach," proceeding of International Workshop on Face and Gesture Recognition, 1995.
29. D. Gavrila, "The Visual Analysis of Human Movement: A Survey," *Computer Vision and Image Understanding*, vol. 73, pp. 82-- 98, 1999.
30. N. Sebe, Ira Cohen, T. Gevers, and T. S. Huang, "Multimodal approaches for emotion recognition: a survey," *Proceedings of the SPIE: Internet Imaging*, pp. 56-67, 2004.
31. I. Murray and J. Arnott, "Toward the simulation of emotion in synthetic speech: A review of the literature of human vocal emotion," *Journal of the Acoustic Society of America*, vol. 93, pp. 1097-1108, 1993.
32. C. Chiu, Y. Chang, and Y. Lai, "The analysis and recognition of human vocal emotions," presented at International Computer Symposium, 1994.
33. F. Dellaert, T. Polzin, and A. Waibel, "Recognizing emotion in speech," presented at International Conf. on Spoken Language Processing, 1996.
34. K. Scherer, "Adding the affective dimension: A new look in speech analysis and synthesis," proceeding of International Conf. on Spoken Language Processing, 1996.
35. Y. Sagisaka, N. Campbell, and N. Higuchi, "Computing Prosody." New York, NY: Springer-Verlag, 1997.
36. I. Murray and J. Arnott, "Synthesizing emotions in speech: Is it time to get excited?," proceeding of International Conf. on Spoken Language Processing, 1996.
37. E. Karkkainen, "Stance taking in conversation: From subjectivity to intersubjectivity," *Text & Talk*, vol. 26, pp. 699-731, 2006.
38. R.-J. Wu, *Stance in Talk: A Conversation Analysis of Mandarin Final Particles*: John Benjamins Publishing Co, 2004.
39. R. Gardner, *When Listeners Talk. Response tokens and listener stance*: John Benjamins Publishing Company, 2001.
40. P. Downing and M. Noonan, "Word Order in DiscourseKim, chapter by Kyu-hyun: WH-clefts and left-dislocation in English conversation: Cases of topicalization." Amsterdam and Philadelphia: John Benjamins., 1995, pp. 247-296.