Combining Context-Awareness with Wearable Computing for Emotion-based Contents Service

Haesung Lee, Joonhee Kwon
Department of Computer Science, Kyonggi University
{seastar0202, kwonjh}@kyonggi.ac.kr

Abstract

One important but often overlooked aspect of human contexts of ubiquitous computing environment is human's emotional status. And, there are no realistic and robust human-centric contents services so far, because there are few considers about combining context awareness computing with wearable computing for improving suitability of contents to each user's needs. In this paper, we discuss combining context awareness computing with wearable computing to develop more effective personalized services. And we propose new algorithms to develop efficiently personalized emotion based content service system.

Keywords: *Context awareness computing, wearable computing, and ubiquitous computing, emotion based content service.*

1. Introduction

With the improvement of human's life, the advent of the mobile era makes human-centric service technologies to be more needed. For development of those technologies, human's emotion is focused from many research fields such as wireless advertising and mobile contents service [1]. Also, together with the remarkable development of wireless sensor network, wearable computing is being important technique for human-centric service in ubiquitous computing environment [2].

Since the 1960s, human's emotion has attracted the attention in various disciplines, such as consumer research, computer science, ergonomics, and marketing. Consumer researchers have studied the influence of experience on consumer behavior. [3] showed that emotional responses to product appearance influence purchase decisions, and [4] discussed the relationship between emotional status and post-purchase product evaluation. Marketing researchers use insight in human's emotion to capture pleasurable or desirable consumer experiences. Then marketing and consumer behavior researchers have focused on consumer emotions and its effect on purchase decisions, post-consumption evaluation and brand loyalty [5]. In computer science, the emotions of human interactions with computational agents were taken as the starting point of the design of the agents in a basic reference in affective computing of Picard [6]. But, most studies related to emotion based computing are in the HCI (Human Computer Interaction) discipline mainly. Therefore, emotion based service systems cannot be extremely effective in various application scenarios so far. Also, there are few considers about combining context awareness computing with wearable computing for improving suitability of contents to each user's needs, there are no realistic and robust human-centric contents services.

The objective of this paper is to propose novel methodological algorithms that employs the convergence of wearable technique, human's emotional context and tagging technique of web in order to develop more realistic and robust emotion based contents services in ubiquitous computing environment. This paper discusses fundamental works about wearable computing and context awareness computing in Section 2. Then, we survey the current trend of researches related to emotion based services to define their drawbacks in Section 2. Also, in this paper, we propose two algorithms for providing various types of emotion based services to each user through combining context awareness computing with wearable computing. The one algorithm for constructing emotion tagged contents repository is represented in Section 4. The other for searching personalized contents based on user's emotional status is represented in Section 5. Two application services are described in Section 6 to show the usefulness of our proposed algorithms.

2. Related Works

2.1. Wearable Computing

With the development of wireless computing and the miniaturization of electrical component, wearable computing systems have drawn a lot of attention from the numerous and yearly increasing corresponding research as one of the key techniques in ubiquitous computing environment. Because of increasing need to personalized services, there has been a need to wearable computing system in order to provide more personalized services to a person [2]. To address this demand, a variety of system prototypes and commercial products such as a smart cloth and an armband have been produced in the course of recent years, which aim at providing real-time feedback information about one's physical condition [7][8].

Especially, for efficient healthcare monitoring system, wearable computing techniques are mainly focused from most researchers of bio informatics domains. Many medical informatics researches like [9] and [10] propose WHMS (wearable health-monitoring systems) which constitute a new means to address the issues of managing and monitoring patients, and persons with their physical condition information.

Fig. 1. The physiological signal sensing system and user interface of human status aware system

Beside medical informatics domain, wearable systems can be integrated into cloths [9]. Smart clothing is made from fabrics that are wireless and washable that integrate computing fibers and materials into the integrity of the fabrics. Reima-Tutta Corporation has introduced the world's first large scale smart clothing prototype, which is intended for the survival in the arctic environment [11]. [12] developed a wearable system, which can sense physiological data, determine emotional status and execute service based on emotion. Figure 1 shows the physiological signal sensing system and the user interface of the human status aware system [12]. The addition of sensors to a cloth allows for the wearable's behavior to be related to the wearer's current activity or situation.

Most applications in ubiquitous computing environment have to provide personalized services to each user without restrictions of the time and locations. However, majority of the existing systems such like what we introduce above have limits to provide human-centric information services because they not consider any ways to find proper contents to a user who potentially wants to find those contents. Therefore, for more useful personalized contents service it is considered to combine context awareness computing with wearable computing.

2.2. Context-awareness

The personalized contents service system belongs to the larger class of context-aware applications as such needs to identify the context within which the individual user is operating. Context-aware computing is a mobile computing paradigm in which applications can discover and take advantage of contextual information. Many researchers have attempted to define the word context. According to [13], context covers information that is of an application's operating environment and that can be sensed by the application. The context information can be categorized as either transient or persistent [14], where the former reflects the environment at a single point in time while the latter is considered as a history of transient context. Schilit[15] considers context as an aggregation of three components namely: Computing context, User context and Physical context.

Context aware applications represented with MediaCup[16] and Chameleon Tables[17]. Context awareness in smart environments has been studied in a number of projects such as ICrafter[18], Gaia[19] and smart kitchen[20]. These previous researches allow us to be conscious of that context-awareness computing must be considered for developing personalized contents services in ubiquitous computing environment. Existing context-awareness applications use various kinds of contexts such as a location context, device context, users around environment context. But, there are few use of human's emotion context for developing context-awareness applications so far.

2.3. Emotion-based service

Scientific findings suggest that emotion plays a significant role in producing rational behavior and rational decision-making [21]. In order to enable computers to recognize the emotional cues from the user it is necessary to record specific autonomic response signals from non invasive bio sensors that can be used in conjunction with a wearable computer for real time portable signal acquisition [22]. Measurements like blood volume (BVP), heart rate (EKG), galvanic skin conductance (SC), and respiratory rate are commonly used in emotion research experiments. Characteristic patterns of these signals have been found which correlate with different self-reported emotional states. The most widely accepted approach is 'valence-arousal dimensions model' [23]; *valence: the discrimination between positive and negative experiences, and arousal: the intensity with which the emotion is experiences*. This model has been widely accepted in many diverse theories and research. Up to the present, the categories of basic emotion for human being have been completely defined with psychological theory or psychological experiments [24][25]. An emotion is characterized as a set of reactions that a human being has when facing several situations. These reactions, which vary from individual to individual, are influenced by each person's personality by the way a person observes the world around him as well as by his emotional state at the time when those situations take place.

Experiments have already shown that it is possible to sense someone's emotions via a skin response sensor. [26] developed the novel mouse, an ordinary computer mouse augmented with a force resistor to detect the dynamic finger pressure, can capture valence information. [27] has measured heart rate and skin conductance while subjects view emotionally evocative stimuli using a computer.

Emotions have an important influence on the life of the human being, influencing many aspects of biological functioning, psychological functioning and social behavior. Therefore, if we want to develop more real and credible personalized service applications, the use of user's emotional information is a much effective approach. Several studies were performed aiming recognizing and simulating emotion in computer system [28][29]. Rosalind Picard studies the use of emotions in informatics systems from the recognition, representation and simulation to the research that involves emotions in human-machine interactions [30]. The other emotion-based application developed at the MIT Media Lab is the ConductiveChat[31]. In incorporate affect arousal information into the text exchanged between two chatting instant messengers. The chat interface uses a user's Galvanic Skin Response (GSR), measured via Galvactivator, to modulate the font color and size as it is typed. The color of the font communicates the user's GSR level and the size of the text relates to the rate of change in GSR within the previous two seconds. Results at [32] show that single emotions such as anger and emotional attributes such as arousal and valence can be identified at a level comparable to human recognition of emotion.

The use of user's physiological signals for the development of efficiently personalized contents service system is very powerful approach to capture user's current emotional status. Therefore, capturing user's current emotional status, we can not only provide more personalized service each person but consider more various application scenarios.

2.4. Wearable system architecture for emotion context

For useful emotion based service, wearable system has to be needed. A wearable system in which various sensors are embedded senses physiological data, determines user's emotional status and triggers different service applications based on emotion.

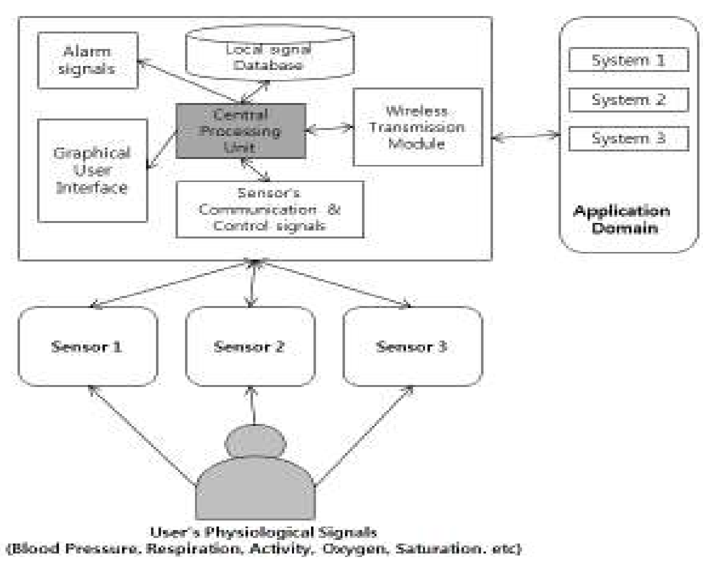

Fig 2. Architecture of general wearable systems

General wearable systems for emotion based services may comprise various types of miniature sensors, wearable or even implantable [33]. These biosensors are capable of measuring significant physiological parameters like heart rate, blood pressure, body and skin temperature, oxygen saturation, respiration rate, etc. The obtained measurements are communicated either via a wireless or wired link to a personalized service system. In fact, emotion based contents service systems in wearable computing environment are may encompass as wide variety of components: sensors, wearable materials, actuators, power supplies, wireless communication modules and links, control and processing units, interface for the user and advanced algorithms for data extracting properly based user's current emotional status.

However, this should not be perceived as the standard system design for various emotion based application scenarios, as many systems may adopt significantly varying architectural approach to various domain specific applications. More specially, a wearable system for emotion based services needs to take into account several wearability criteria, for instance, the weight and the size factor of the system need to be kept small and the system should not hinder any of the user's movements or actions during the capture process of the user's emotional status.

3. Overview of Emotion-based Contents Service

The development of wireless computing and the miniaturization of electrical components have accelerated the production of different mobile devices such as smart phones, wrest computing devices, and net books.

Because of the advance of wireless computing and those various types of computing devices, it is possible that human's needs to various personalized services much increase. For various scenarios of emotion based contents services, we define a wearable system which is composed of four layers depicted in Fig 3.

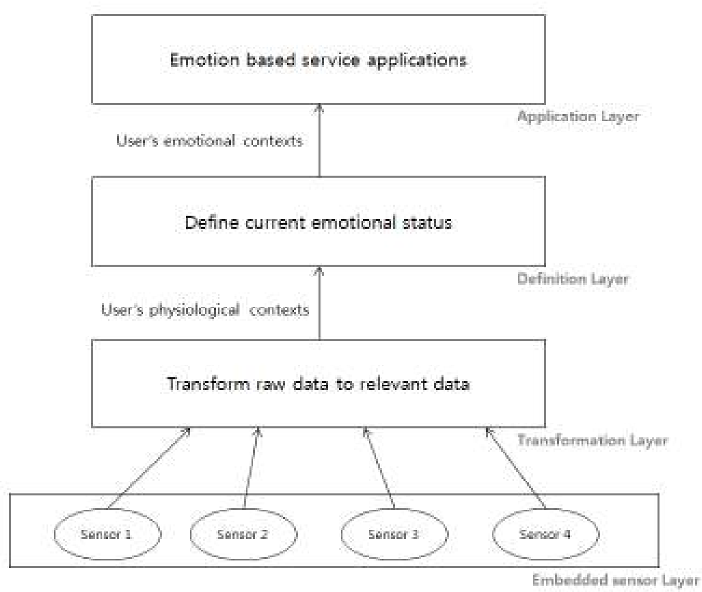

Fig. 3. Four layered wearable system of emotion based contents services

Also, we proposed an architecture for various emotion based services. Our proposed architecture is applied in various service application domains such as multimedia services, advertising services and smart home services. Therefore, using our architecture, the various types of applications are considered.

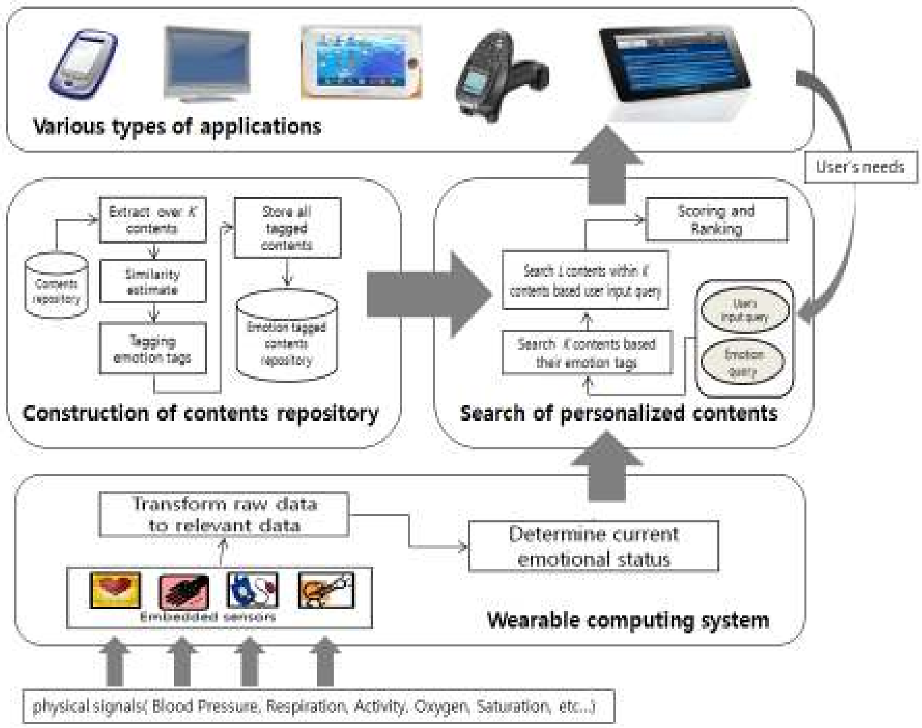

Fig 4. The Architecture for Emotion based contents services

Figure 4 depicts our proposed architecture. Key concepts of proposed architecture are:

- A wearable computing system senses physiological data, determines emotional status and executes a service based human's emotion.
- Emotion tagged contents repository described in chapter 4 is used in the process of searching contents proper user's needs and user's emotional status. To construct emotion tagged contents repository, we propose emotion tagging process in chapter 4.
- In the process of searching contents based on emotion described in chapter 5, two types of queries are used; *user's input query, automatically generated emotion query*, in order to provide more realistic and personalized services. And the process of searching contents consists of two phrases. The first phrase is extracting contents based on an emotion query. Then, in second phrase, the final set of contents is extracted based on user's input query.
- Before providing emotionally personalized contents to a user, the ultimately extracted contents are ordered by a scoring and ranking function in order to choose only one or high ranked contents.

4 Construction of Emotion Tagged Contents Repository

Tagging is not only an individual process of categorization, but implicitly it is also a social process of indexing. In IR (information retrieval), a tag is means of tag querying. In this paper, we use tagging technique for tagging emotion tags on each content. But, our proposed tagging process is more automatic than typical things.

Fig 5 depicts the example of the *k* emotion tagged content. In this example, the content 'Toy story 3' features happiness because the similarity between the content 'Toy story 3' and the contents represent 'happiness' is the highest among other emotion tags.

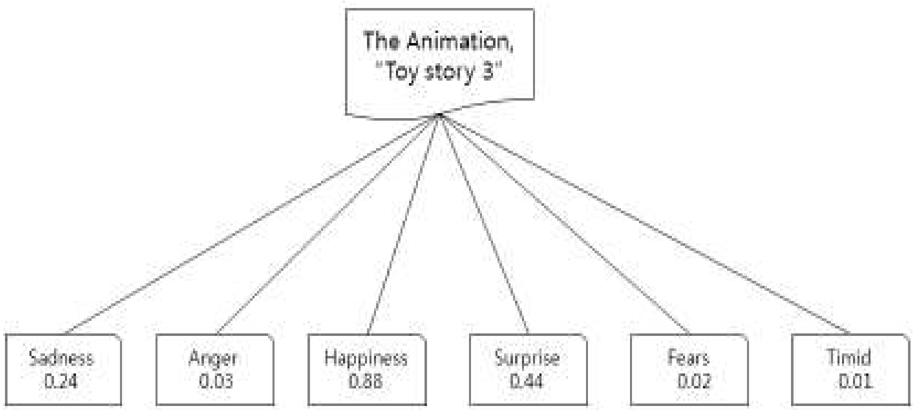

Fig 5. The example of emotion tagged content

Follow description is steps for constructing emotion tagged contents repository composed like the example of Fig 5.

Step1 Suppose that some experts extract over *k* contents represent *k* different basic emotions. So, let $E(C_k)$ the set of contents represent each basic emotion. For example, if we use the categories of six basic emotions; sadness, anger, happiness, surprise, fears and timid, we can extract over six contents representing these six different emotions. Therefore, C_1 is the content represent sadness, C_2 is the content represent anger and so on. The fact that extracting represented contents is done manually by some experts could take advantage of a better reflection of the human perception.

Step2 Compute *k* similarities for one of all contents stored in contents repository through comparing $E(C_k)$ with each of all contents. In the example described above, we can compute six values of the similarity for each of all contents. In other words, we define emotional feature of content by considering similarity between each content and *k* contents representing basic *k* emotions.

Step3 Based on computed *k* similarities in the previous step, we tag *k* tags on each content. An emotion tag describes which emotion is featured for a content on which the tag is tagged and similarity between the featured emotion and the content.

Step4. Store all emotion tagged contents in emotion tagged contents repository which is used in the process of searching personalized contents.

With the description above, we define an algorithm for constructing emotion tagged contents repository. The table 1 represents the pseudo algorithm of constructing emotion tagged contents repository.

Table 1. Pseudo algorithm for Constructing emotion tagged contents repository

```
Algorithm 1.
Constructing_Emotion_Tagged_Contents_Repository()
    BEGIN.
    C  =  the set of all contents stored in the repository R;
    E  = the set of content represent of k different basic emotions;
    Array[the number of items in C ][the number of items in E ]=Compute_Simlarity(C,E );
    FOR i = 1 to the number of items in C by i++
        FOR j = 0 to the number of items in E by j++
            IF( Array[i][j] > the value of the threshold) THEN
                Do tag an emotional tag describing emotional information and the value of
                similarity on C_i ;
        Do store C_i to the repository ER ;
    END.

Array[][] Compute_Similairy(C, E)
    BEGIN.
    SimArray[the number of items in C][the number of items in E] ;
    FOR i =1 to the number of items in C by i++
        FOR j = 0 to the number of items in E by j++
            Do compute the similarity ES between C_i and E_j ;
            SimArray[i][j] = ES;
    RETURN SimArray;
    END.
```

5 Search of Personalized Contents

In this chapter, we propose an algorithm to provide proper personalized contents to a user based his emotional status. To find appropriately personalized contents, we use emotion tagged contents repository proposed in preceding chapter 4 and user's emotional context returned from a wearable system.

Follow description is steps for searching personalized contents based user's current emotional status.

Step1 Set two queries for query based search process. Suppose that the one of two queries inputted by a user presents the category of contents. If a user wants to see a movie not to listen to music, the user oneself input a term movie as a query. Another is the emotion query which is automatically generated and inputted to searching process by the wearable system described in chapter 3. Therefore, the two types of the query are used to search proper contents to user's need and user's emotional status.

Step2 *k* contents are extracted from emotion tagged contents repository through exact matching the emotion query with emotion tags which are tagged on contents within emotion tagged contents repository.

Step3 y contents are extracted from k contents $(y \leq k)$ by checking whether each of k contents is related to user's input query or not. In other words, this step decides which contents belong to the category which is needed by the user.

Step4. Previous extracted contents are ordered through the process of scoring and ranking by their relevance with user's needs and user's emotional status. Therefore, the top content or top k contents among ordered contents are provided to each user.

Based on description above, we define an algorithm for constructing emotion tagged contents repository. The table 2 represents the pseudo algorithm of constructing emotion tagged contents repository.

Table 2. Pseudo algorithm for constructing emotion tagged contents repository

```
Algorithm 2.
List Searching_Cotents( categoryQeury, emotional Query )
BEGIN.
List  found_eq = NULL;
List  found_cq = NULL;
List  result = NULL;
EC = the set of contents stored in the emotion tagged contents repository;
FOR  i = 0 to the number of items in EC by i++
    IF ( emotionalQuery is equal to emotion tag of EC_i )
        Do add EC_i to found_eq;
FOR  j = 0 to the number of items in found_eq by j++
    IF ( the category of found_eq_j is related to categoryQuery )
        Do add found_eq_j to found_cq;
result = OrderingBySimilarity(found_cq);
RETURN result;
END.
```

6. Scenario

With our proposed approach, it is possible to consider various personalized service domains such as a music streaming service, mobile advertising contents service or media streaming service. The follow scenarios describe examples of possible cases to which our proposed approach can be applied.

- ***Scenario 1(in a case of media streaming service application)***.
  User A is in sadness emotional status because he wrangled with his girl friend. In time, he wants to see a movie and inputs a category query 'movie' in the application which uses our proposed approach. And the wearable system embedded in the application captures user A's current physical signals and define his current emotional status based on the captured physical signals. In this case, using our proposed approach, the system can provide a movie which is to be brightly happy ending not horror or sad ending.

- ***Scenario 2(in a case of music streaming service application).***
  User B fails to get to sleep as her emotional status are much fears and surprised. So, user B wants to listen to music while she lies down on the bed and just turn on the music online streaming service application without inputting any queries. The wearable system attached to the application capture *user B'*s current physical signals, define her current emotional status based on the captured physical signals and transfer her emotion contexts to the application. In this case, the application based on our approach automatically generates two type queries, one is category query, and *'music'* and another is emotional queries, *'fears'*and *'surprised'* which are returned from the wearable system. Then, through searching process described in the above chapter, the application can provide comfortable music proper to insomnia not rock music or dance music.

However, most previous applications are only consider case specific approaches. So, their approach cannot be applied to other service domains. And existing emotion based services are no consider about personalized searching methods so far. Therefore, they have some restrictions of providing personalized contents to each user appropriately. To develop realistic and robust human-centric contents services like scenarios described above, it is very useful for emotion based services to combine context awareness computing with wearable computing for improving suitability of contents to each user's needs.

7 Conclusions

With the improvement of human's life, the advent of the mobile era makes human-centric service technologies to be more needed. For development of those technologies, human's emotion is focused from many researches. Also, together with the remarkable development of wireless sensor network, wearable computing is being important technique for human-centric service in ubiquitous computing environment. However, there are no realistic and robust human-centric contents services so far because there are few considers about combining context awareness computing with wearable computing for improving suitability of contents to each user's needs.

In this paper, we propose a novel methodological algorithm that employs the convergence of wearable technique, human's emotional context and tagging technique of web in order to develop more realistic and robust human-centric services. The one algorithm is for constructing emotion tagged contents repository using tagging technique and the other is for searching personalized contents based user's current emotional status. For applying our algorithm, we define a wearable system which is composed of four layers. In our algorithms, emotion context tagging technique is very useful in combining context awareness computing with wearable computing. The one of among advantages of the use our proposed algorithms is the possibility of considering various service domain applications. So, more appropriate contents can be provided to each user based their emotional status through our proposed algorithms.

Acknowledgment

This work was supported by the Gyonggi Regional Research Center (GRRC) and Contents Convergence Software (CCS) research center.

References

1. L. Gatzoulis and I. Iakovidis, “Wearable and portable health systems,” *IEEE Eng. Med. Biol. Mag.*, vol. 26, no. 5, pp. 51–56, Sep.–Oct. 2007.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, pp.68–73, 1892.
2. P. Bonato, “Advances in wearable technology and applications in physical medicine and rehabilitation,” *J. NeuroEng. Rehabil.*, vol. 2, p. 2, Feb. 2005.
3. Creusen, M.E.H, “Product Appearance and Consumer Choice”, Delft University of Technology, Delft, 1998
4. Oliver, R.L., “Cognitive, Affective, and Attribute Bases of the Satisfaction Response”, Journal of Consumer Research, (20), pp. 418-430, 1993.
5. Rinchins, M.L, “Measuring Emotions in the Consumption Experience”, Journal of Consumer Research, (24), pp. 127-146, 1997.
6. Picard, R.W., “Affective Computing”, MIT Press, Cambridge, 1997.
7. P. Bonato, “Wearable sensors/systems and their impact on biomedical engineering.”*, IEEE Eng, Med,. Biol. Mag.,* vol. 22, no. 3, pp.18-20, 2001.
8. Jonny Farringdon, Andrew J. Moore, Nancy Tilbury, James Church and Pieter D. Biemoon, “Wearable Sensor Badge and Sensor Jacket for Context Awareness”, *Proceddings of the 3rd IEEE International Symposium on Wearable Computers*, pp. 107, 1999.
9. G. Troster, “The Agenda of Wearable Healthcare”. In IMIA Yearbook of Medical Informatics, Stuttgart, Germany:Schattauer, 2005, pp. 125-138, 2007.
10. A. Lymperis and A. Dittmar, “Advanced wearable health systems and applications, research and development efforts in the european union,” *IEEE Eng. Med. Biol. Mag.*, vol. 26, no. 3, pp. 29–33, May 2007.
11. JAKICIC, J. M., M. MARCUS, K. I. GALLAGHER, C. RANDALL, E. THOMAS, F. L. GOSS, and R. J. ROBERTSON. “Evaluation of the SenseWear Pro Armband™ to Assess Energy Expenditure during Exercise”. *Med. Sci. Sports Exerc.*, Vol. 36, No. 5, pp. 897-904, 2004.
12. Dong-Wan Ryoo, Young-Sung Kim and Jeun-Woo Lee, “Wearable System for Service based on Physiological Signals”, Proceedings of the 2005 IEEE, Engineering in Medicine and Biology 27th Annual Conference, pp. 2437-2440, 2005.
13. D. Salber, A. Dey and G. Abowd, “The Context Toolkit: Aiding the Development of Context-Enabled Applications”, In Proc. Of CHI’99, ACM Press, Pittsburg, Germany, 2001.
14. M.R. Ebling, G.D.H. Hunt, and H. Lei, “Issues for context services for pervasive computing”, In Proc. Of the Workshop on Middleware for Mobile Computing, Germany, 2001.
15. B. Shilit, N. Adams, and R. Want, “Context-aware computing applications. In Proc. Of IEEE workshop on Mobile Computing Systems and Applications, IEEE Computer Society Press, Santa Curz, California, pp. 85-90, 1994.
16. H. Gellersen, M. Beigl and H. Krull, “The MediaCup:Awareness technology embedded in an everyday object.”, in 1st International Symposium on Handheld and Ubiquitous Computing(HUC99), pp. 308-310, 1999.
17. T. Selker, E. Arroyo and W. Burleson, "Chameleon tables: Using context information in everyday objects," in CHI '02: CHI'02 Extended Abstracts on Human Factors in Computing Systems, 2002, pp. 580-581.
18. S. Ponnekanti, B. Lee, A. Fox, P. Hanrahan and T.Winograd, "ICrafter: A service framework for ubiquitous computing environments," in UbiComp '01: Proceedings of the 3rd International Conference on Ubiquitous Computing, 2001, pp. 56-75.
19. S. Chetan, "Mobile Gaia: a middleware for ad-hoc pervasive computing," Consumer Communications and Networking Conference, 2005. CCNC. 2005 Second IEEE, pp.223-228, 2005.
20. E. Kotsovinos and M. Vukovic, "su-chef: Adaptive coordination of intelligent home environments," Autonomic and Autonomous Systems and International Conference on Networking and Services, 2005. ICAS-ICNS 2005. Joint International Conference on, pp. 74-74, 2005.
21. Picard R., “Affective Computing”, MIT Press, Cambridge, 1997.
22. Thad Stanrner, “Augmented reality through wearable computing”, TR 397, MIT Media Laboratory, MIT Media Laboratory: Perceptual Computing, Cambridge, 1997.

23. Heller, W., Nitschke, J. B., Etienne, M. A., & Miller, G. A. (1997). Patterns of regional brain activity differentiate types of anxiety. Journal of Abnormal Psychology, 106, 376–385.
24. Ortony, Andrew, and Turner, Terence J, "What's basic about basic emotions?", *Psychological Review, 97*, pp. 315-331, 1990.
25. Plutchik, Robert, "The Multifactor-Analytic Theory of Emotion", *the Journal of Psychology, 50*, pp. 153-171, 1960.
26. Dana Krish, "The Sentic Mouse: Developing a tool for Measuring Emotional Valence", MIT, Department of Brain and Cognitive Sciences, May 1997.
27. Ward Winton, Lois Putnam, and Robert Krauss, "Facial and autonomic manifestations of the dimensional structure of emotion", Journal of Experimental Social Psychology, pp. 195-216, 1984.
28. Gratch, J. and Marsella, S. 2006. Evaluation a computational model of emtion. Journal of Autonomous Agents and Multiagent Systems, 11(1), pp. 23-43, 2006.
29. Hudicka, E. 2006, "Depth of Feelings: Alternatives for Modeling Affect in User Models", pp. 13-18, 2006.
30. Picard, R. "Affective Computing", M.I.T Media Laboratory Perceptual Computing Section Technical Report, V. 321, Nov. 26, 1995. [on-line] Available: http://vismod.media.mit.edu/tech-reports/TR-321.pdf [Sep 21. 2008]
31. A.T. Fiore, V. Lakshmipathy and J. M. Dimicco, "ConductiveChat: A Galvactivator-Enhanced Instant Messenger Client:, available at: http://web.media.mit. edu/~joanie/affect/
32. Fickas, S., Kortuem, G and Segall, Z, "Software organization for dynamic and adaptable wearable systems", In proc. of Wearable Computers, Digest of Papers, First International Symposium, pp. 56-63, 1997.
33. Krupaviciute, A., Fayn, J., Rubel, P., Verdier, C., McAdams, E., and Nugent, C., "Information System Architecture for Wearable Cardiac Sensors Personalization". In Proc. of Engineering of Complex Computer Systems, 14th IEEE International Conference, pp. 265-272, 2009.

Authors

Haesung Lee received the B.S. and M.S. degree in Computer Science from Kyonggi University, Suwon-si, Kyonggi-do, Korea in 2008 and 2010, respectively. She is currently working towards the Ph.D degree in the department of Computer Science, Kyonggi University. Her research interest includes context awareness computing, mobile computing and information retrieval.

Joonhee Kwon received the B.S., M.S., and Ph.D. degree in Computer Science from Sookmyung Women's University, Seoul, Korea in 1992, 1994, and 2002, respectively. She is currently a professor, Dept. of Computer Science, Kyonggi University, Suwon-si, Kyonggi-do, Korea. Her research interests are ubiquitous computing, context awareness computing, and database.