

Aesthetics as a Key Dimension for Designing Ubiquitous Entertainment Systems

Ben Salem, Matthias Rauterberg

Department of Industrial Design, Technical University Eindhoven, The Netherlands.
{b.i.salem, g.w.m.rauterberg}@tue.nl

Abstract. In this paper we review the current understanding of aesthetics. There are three aspects to aesthetics namely: the form, the action and the experience. We explore these aspects and highlight their relevance for entertainment. We then investigate ubiquitous entertainment systems notably from an interaction point of view. We advocate and define how ubiquitous entertainment could and should rely on aesthetics as a framework for the delivery of usable systems.

1 Introduction

Nowadays, enabled by the omnipresence of the Internet and mobile communication, it is possible to have access to information and communication technology (ICT) services continuously and uninterrupted. Ubiquitous computing (UbiComp) as defined by Weiser (1991) is becoming a reality. While this holds true for office application (diary, emails, etc.) and communication services (telephone, SMS), progresses are still needed for ubiquitous entertainment systems (UES).



(a) Blackberry
(Blackberry, 2005)



(b) N-Gage
(Symbian, 2005)



(c) Gameboy
(JapanToday, 2005)

Figure 1. Selected examples for ubiquitous entertainment systems: (a) Mobile phone handsets have evolved into encompassing PDA and Pocket PC functionalities such as the Blackberry; (b) gaming platforms for multiplayer games have been integrated into a phone; (c) a Gameboy platform has been extended to support videophone services.

There are some emerging mobile phones that provide some gaming, media and entertainment services such as shown in figure 1. It is the advent of various wireless networks and their associated services that is helping making UES a reality. Today ICT devices can connect to a combination of networks such as global system for mo-

bile communication (GSM), wireless fidelity (WiFi) for local area networks (LAN) and Bluetooth for short range connections. One can always rely on some connection shall s/he be at home, at work, on the move, or even in some of the most unexpected location such as remote fields in Africa (Cronin, 2004). As a result UES are now a potential major new application area in ICT services.

One of the major issues that needs addressing for the widespread of UES is the selection of the correct evaluation and assessment criteria (Jordan, 1998; Lavie and Tractinsky, 2004). While the criteria for entertainment systems falls within the realm of hardware design, ubiquitous entertainment services are about more than software development. If entertainment turns ubiquitous, then the user experience gain paramount importance and relevance (Overbeeke and Wensveen, 2003; Sengers et. al., 2004). It is the quality of the experience resulting from such a service that should be used as a benchmark for the development of ubiquitous entertainment. Within this perspective, we advocate that it is the aesthetic of the experience that in essence should be used as a measurement of the suitability of an entertainment service. Nakatsu, Rauterberg and Vorderer (2005, p. 9) pointed out that among others aesthetics should be systematically connected to entertainment theory. Let us first define and explain the concept of aesthetic within the context of entertainment and then demonstrate how it could be used as part of design guidelines for ubiquitous entertainment.

Aesthetics is a concept that could be defined, explained and explored in many ways and still remains as evasive and unknown as it was (e.g., *iki* as an aesthetic ideal for everyday live in Japan, Yamamoto, 1999). What is aesthetics and why as humans we have sought and are seeking aesthetics? Such questions could be helpful for a better understanding of the concept. Unfortunately answering it is not as straightforward as one would like. In general, aesthetic can be associated with the concept of beauty, and in one sense, aesthetics is the measurement of beauty. Such a measure is probably associated with pleasure. Thus featuring beauty yields aesthetic pleasantness (Berlyne, 1960). Mentioning pleasantness implies a key fact about aesthetic: that aesthetics is experienced and lies in the mind of the observer or rather the beholder of the experience (Matravers, 2003). This makes the concept rather subjective and difficult to quantify. Furthermore, beauty needs not, within this context, be limited to visual beauty. Any of our senses could be involved as well (Suzuki, 1959; Servomaa, 2001). So to redefine the concept in a more encompassing way, it is better to say that aesthetic is a subjective assessment of the beauty of an experience (Arcilla, 2002).

The beauty of an experience can in turn be translated into the pleasantness of the experience (e.g., 'tea ceremony' discussed by Ekuan, 1998, p. 28ff). In turn the pleasantness of an experience relates to the emotions triggered and their intensity. The emotional outcome of an experience is an essential part of its aesthetic assessment, since emotions have a hedonistic bias in their occurrence (Cupchik, 1994, p. 183ff). The aesthetic experience is ultimately about a satisfaction resulting from the experience. Cupchik (1994) discusses two principles from pragmatic and emotional processing in everyday life that are generalized to the aesthetic realm. In everyday processing, ecologically important stimulus configurations are linked with bodily feelings of pleasure and arousal (Berlyne, 1960). In addition, meanings which are contingent on specific contexts are associated with blends of primary emotions (Millis, 2001). Aesthetics has therefore any combination of the following four key components: (1) beauty, (2) pleasantness, (3) emotions, and (4) satisfaction. Aesthetics could result

from exposure to a perceivable form (e.g., physical, acoustic, olfactorial), the performance of an action (e.g., body expression, motor activity, etc.) or simply a mental experience (e.g., reading a book, meditation, etc.); see also the concept of *integrated presence* in Nakatsu, Rauterberg and Vorderer (2004).

1.1 Aesthetics of the Form and Content

The classical understanding of aesthetics relates it to the perception of physical beauty and balance. It is about the perception of proportions, symmetry, harmony and appearance (e.g., Locher, Stappers and Overbeeke, 1998). This kind of aesthetics is relevant to entertainment in the sense of the forms, the sound and other elements used. This kind of aesthetics does not relate only to visual form and content. Sounds, for example music and other modalities are involved as well. In effect any of our senses let us experience aesthetics of this kind. And thus a synergetic combination of sense in a multimodal experience will yield a stronger experience of aesthetics. This would occur when one modality reinforces the perception resulting from another, e.g. sound and image render the same message (Karat et. al., 2002). Human experience can take several forms that can be used in a UES. The experience can be sensory (how we perceive), synesthetic (how we combine perception), cognitive (how we think), autonomic (how our ‘gut feeling’ tells us we feel), and motoric (how we act and do). This is of particular relevance for the developer of an aesthetic pleasing UES.

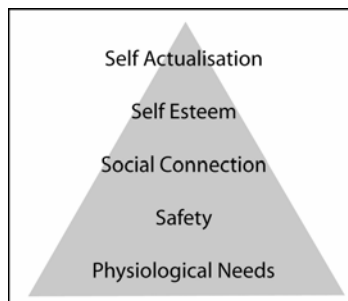


Figure 2. Human needs as described by Maslow. From bottom to top the fulfilment of any level will result in the experience of satisfaction (adopted from Maslow, 1970).

1.2 Aesthetics of the Movement and Action

It is an understanding of aesthetics inspired from the world of performing art such as mime theatre and dance. This aspect of aesthetics is related to the perceived quality of performed movements and actions, such as the strength shown by an athlete while running the 100mtrs, the lightness of a ballet dancer and the caricatured gestures of a mime performer. The aesthetics of the movements can also be related to ones movements and actions. Yamamoto (1999, p. 33) relates the Japanese concept *iki* even to daily behaviour. Within this context the main criteria used for the assessment of the

movements relates to their fulfilment of Maslow pyramid of needs as illustrated in figure 2 (Maslow, 1970).

We have extended this to ones *needs, requirements* and *desires* (NRD; Salem and Rauterberg, 2004). In our proposed NRD model, the self is at the centre, and all needs requirements and desires radiate from it. It is an egocentric, egoistic and hedonistic model. In our model, needs relates to the *essentials*, requirements to the *necessary* and desires to the *optionals*. While performing a movement or an action, it is possible to assess them in terms of their effect on NRD. Thus the fulfilment of one of the NRD would yield a positive aesthetic experience of the movement or the action. Extending an aesthetic concept such as *iki* (Japanese Aesthetics, 2005) to the aesthetics of movement and action will probably leads us directly to the aesthetics of experiences.

1.3 Aesthetics of the Experience

An aesthetics experience can have either of three origins: (1) the aesthetics of the perception (AoP), (2) the aesthetics of the cognition (AoC; Cupchik, 1994), or (3) the aesthetics of the action (AoA). In all three cases aesthetics relate to the experience one has and his/her assessment of it. Aesthetics are related to subjective, personal, changing and sometimes irrational aspects of one's life. This could be for example the way one feels after watching a movie (AoP), listening to some music (AoP), looking at some painting (AoP), having a break-through idea or a deep insight (AoC), or highly immersed dancing (AoA). Experiencing the serenity of the Japanese *tea ceremony* is probably one of the most advanced experiences with high aesthetic value (Suzuki, 1959). Developed in the 16th century as a means to achieve inner harmony with nature, the tea ceremony is a highly ritualized process that takes years to learn. AoP, AoC and AoA are also related to the emotional response that is triggered by the experience. What is mostly relevant in the area of UES is the general idea that if one would be using an entertainment system that would be omnipresent, it might be necessary to go beyond entertainment that provides leisure time to an entertainment that provides an experience rich with aesthetics. "The house becomes not just an inanimate container but an active and interesting member of the family: reminding, assuring, entertaining, and playing with the family" (Bushnell, 1996, p. 36).

2 Social Aesthetics

While so far we have explained aesthetics from a personal point of view, there is another aspect of aesthetics that is of relevance in the context of ubiquitous entertainment. Some examples of social aesthetics would be related to trends, culture or religions. Within the context of entertainment we wish to focus on social aesthetics related to culture (see also Rauterberg, 2004). Culture has long been associated with arts, leisure and entertainment. It seems therefore a good focus point that we wish to develop further. "The growing influence and control of market forces in society means that people will be able to take an easier attitude toward art and that the whole concept of art as an antithesis of entertainment or mass culture will be called into question" (Alasuutari, 2001, p. 179).

2.1 Culture and Society

Every society has to ground its identity in the historical development of its own culture. We can distinguish three main components: (1) the shared set of norms, values, beliefs and attitudes, (2) the created and used artefacts, and (3) the people as constituting members of the society (see figure 3). These three elements relate to each other in a closed loop. Based on the belief system the people determine their relationship among each other, but also what kind of artefacts will be created and accepted. Using these artefacts confirms and determines the way of thinking and acting. Any societal change can be caused by three different, almost independent processes: (1) development of the belief system, (2) technical and industrial driven inventions, and (3) the behavioural codex changes of people. “The rise of Nintendo and the Japanization of the game business that occurred in the late 1980s created perhaps the most extensive import of foreign culture that has happened in America other than through immigration” (Bushnell, 1996, p. 33).

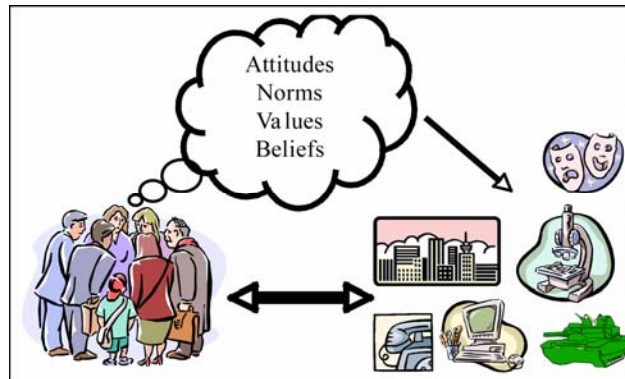


Figure 3. The three main components of any society and their cyclic relationship (norms & beliefs, artefacts & products, people).

Having explained the concept of culture within a societal context, aesthetics could be associated with culture. This could be achieved by seeking experiences that would deliver any of a beautiful, pleasant, emotional, or satisfactory experience in the cultural domain. While having an aesthetic experience of this kind it is not so much the personal experience that is assessed but rather the compliance, caricature, or questioning of society’s cultural values by the source of the aesthetic experience.

3 Designing Ubiquitous Entertainment Systems

The proliferation of ICT infrastructure in our environment, will lead to ubiquitous IT systems becoming a reality and furthermore to the emergence of new interaction principles. This is even truer for entertainment systems. Such systems are not used out of necessity such as for work or convenience, they are used for to provide amusement,

pleasure and satisfaction. It is therefore important to design UES to deliver an adequate interactive experience.

Designing an interactive system we can distinguish three different views: (1) system centred view, (2) user centred view, and (3) interactions centred view (see figure 4). Historically the system view preferred by engineers dominated and is today accompanied with the user centred view promoted by user interface designers (Karat et al., 2002). In this paper we argue for the third option: the *interaction centred view*. Since UES are about delivering a user experience which is entirely based on the interactive process. One of the first questions to address is how to describe the interaction, and second what are the criteria for an aesthetic pleasing interactive process.

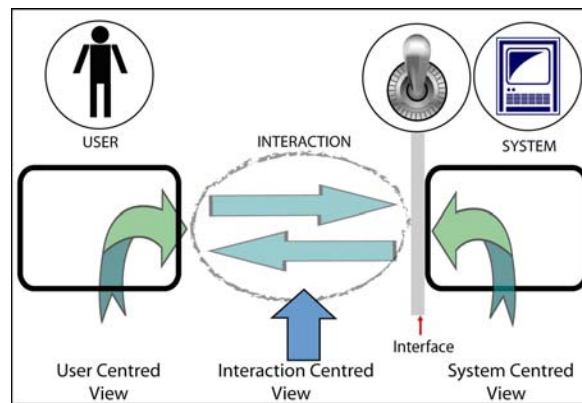


Figure 4. The three main views to interaction design: user centred, interaction centred and system centred.

Before we can describe the ‘interaction centred view’, we will briefly discuss the shortcomings of the two other views. Engineers prefer the system centred view because the main target of their activities is the design and implementation of the technical part. Since 1980 the critique formulated by the human computer interaction community concentrates on the insufficient and unusable user interfaces. To overcome these constraints the user centred view was developed and propagated (Rauterberg, Strohm, Kirsch, 1995). But both views do not concentrate on the nature of the interaction in itself. To address the nature of interaction we have to realise that interaction is a dynamic relation between two different components: the user and the system. Both, user and system have an ‘interface’, the human’s interface is almost genetically determined (except the learning potential of the brain), and the system’s interface is the free space for design. Therefore it was and still is not entirely arbitrary to focus and concentrate mainly on the system’s interface, but it will be not enough.

The view to adopt while designing the interface for ubiquitous systems have developed in four user interface paradigms: (1) natural, (2) context aware, (3) automated capture and access, and (4) always available (Abowd and Mynatt, 2000). For UES the requirements are more stringent and the four paradigms one should be reviewed as following: (1) natural and highly usable, (2) context aware and adapted, (3) automated and biased capture and access, (4) always available but not invasive.

3.1 Interaction Design

Four concepts are of importance during the interaction: (1) the dimension of the user internal world model, (2) the presentation effect of the interface, (3) the perception mechanism, and (4) the conceptualisation of the world dimensions in the user's model (e.g., Rauterberg and Szabo, 1995). A major problem in designing user interfaces is the fact that interaction designers do not have any established metrics or benchmarks for applying the optimal software and hardware system within the context of UES. Table 1 is a first attempt to identify some benchmarks.

Table 1. Some benchmarks for Ubiquitous Entertainment Systems

Domains	Dimensions
Focus Shifts	Connections and relations between the immediate surroundings and the entertainment services
Interruption	Moving from foreground to background, gradual and on-time fading, delivering services at different levels
Multitasking	Multi-modality, association and clear separations
Scalability	Plug and play modules, ad hoc network topology
Segmentation	Where is the beginning where is the end, Clear recalls and clues
Social Issues	Multi-user integration and experiences
Timing and Duration	In line with user focus and interests, continuous entertainment, but timely events
User Actions	Planned and spontaneous interaction. Multiple granularity levels
User's Needs	Compelling and relevant applications

The requirements of UES take us away from the Windows, Icon, Menu, Pointer (WIMP) interface into more natural ones such as non verbal communication, speech, gestures, tangible and wearable UI (Rauterberg and Steiger, 1996; Nakatsu, 1998). As for context awareness this can range from location and activity dependant services to the selection of relevant services (Salem and Rauterberg, 2004).

3.2 Examples of Emerging Technology

Nakatsu and Tosa (1997) proposed a new type of media called 'interactive movies' which can be realized by the integration of conventional medium such as movies, telecommunications, and video games. The interactive movies have the capability of creating a virtual world with various kinds of hyper-realistic scenes and computer characters. The metaphor of 'Inter Communication Theater' enables people to interact within this virtual world. Therefore people can experience the stories of the virtual world through interactions with the characters and the environments of the artificial world.

Tosa and Nakatsu (2000) introduced a means of 'touching the heart' in a new way by measuring the heartbeat of the 'honest' body and using advanced technologies to develop a new code of non-verbal communications (see Nakatsu, 1998) from a hidden or subconscious dimension in society. They call this approach 'meditation art' or 'Zen art' based interactive experience design.

Tosa and Matsuoka (2003) developed the ZENetic computer that could help recreate conscious selves by calling on Buddhist principles through the inspirational media of ink painting, kimono and haiku. 'Recreating our selves' means the process of making the consciousness of our 'daily self' meet that of our unconscious and 'hidden self' through rediscovering creative resources deep within us that may have been forgotten but still resonate with vital meaning. The ZENetic computer is based on the design to meld the consciousness and unconsciousness in complete harmony.

4 Key Dimensions for Ubiquitous Entertainment

While entertainment is essentially about grabbing one's attentions with the intention of delivering an experience, a satisfaction, an amusement or a pleasant time. Ubiquitous entertainment is therefore about delivering the same but in a ubiquitous context. From the user interaction view the key dimensions are: (1) natural and usable, (2) context aware and adapted, (3) automated capture and access, and (4) always available but not invasive. From the user experience view the key dimensions are: (1) beauty, (2) pleasantness, (3) emotions, (4) satisfactions, and (5) aesthetic experiences.

Context awareness and adaptation yields an experience fusion between the reality the user is in and the entertainment service s/he is enjoying. The system is aware of its own state and in relation with other systems notably those that relate to its user(s). The UES is aware of user intentions, tasks and relevant aspects of his state of mind. It can accordingly, change autonomously its operation mode and characteristics. From the user perspective there is apperception of adaptivity. If in addition the interaction is made natural and highly usable, there is perception of augmented reality. In the sense that the user's experience of reality is augmented with his/her experience of the entertainment services. It is a concept of environments fusion/juxtaposition.

Furthermore, automated capture and access are necessary for the awareness and adaptation, they imply electronic-diary type of event capture and body movement and actions tracking. Access ensures continuous availability but avoid perception of invasiveness by adopting an on-demand approach. Thus a user pull rather than a system push configuration. The UES should be highly usable; usability relates to the effectiveness, efficiency and satisfaction with which an individual would use such a system. Effectiveness relates to how good the system is at causing/achieving the desired results. Efficiency is about how minimal are the resources to achieve the desired results. As for user satisfaction it relates to the user experience and its aesthetics (see Jordan, 1998; Overbeeke et. al., 2002; Overbeeke and Wensveen, 2003).

5 Conclusion

In the age of ubiquitous IT services, entertainment is poised to play a major role in our everyday lives. We feel it would be important to highlight as part of the user experience aesthetics as a key dimension that could be used as a benchmark. What are the consequences of a ubiquitous society on entertainment? How will it affect the way we access and experience entertainment? Good examples of inspiration are theatre

which renders society through the vision of the script writer (e.g., Nakatsu and Tosa, 1997). Of particular interest are popular theatre styles such as improvised street theatre and mime theatre. In these styles society is caricatured and some archetypical social characters are portrayed with emphasis on their peculiarity. Throughout the antiquity, and until the mid 20th century, people had to go to the dedicated infrastructure or in the street to enjoy theatre. Since then Television has allowed for a more accessible entertainment. At the same time theatre has evolved into acting, movies and series. UES are poised to deliver new entertainments genres and experiences (e.g., from Sony's PlayStation Portable to ZENetic computers). Let's make sure that this development will result not in a new generation of 'dependent' users but a new form of enrichment and finally a new way for enlightenment.

References

- (All websites listed were last visited on 31st July 2005.)
- Abowd, G.D., Mynatt, E.D. (2000). Charting Past, Present, and Future Research in Ubiquitous Computing. *ACM Transaction on Computer-Human Interaction*, 7(1), pp. 29-58.
- Alasuutari, P. (2001). Art, entertainment, culture, and nation. *Cultural Studies ↔ Critical Methodologies*, 1(2), pp. 157-184.
- Arcilla, R.V. (2002). Modernising media or modernist medium? The struggle for liberal learning in our information age. *Journal of Philosophy of Education*, 36(3), pp. 457-465.
- Bai, H. (2003). Learning from Zen arts: a lesson in intrinsic valuation. *Journal of the Canadian Association for Curriculum Studies*, 1(2), pp. 39-54.
- Berlyne, D.E. (1960). *Conflict, arousal, and curiosity*. McGraw Hill.
- Blackberry (2005). Website, <http://www.blackberry.com/products/blackberry7200/blackberry7270.shtml>
- Bruns, W., Richard, J. (2004). Aesthetic cybernetics—turning towards senses of man and machine. In: Proc. *International Conference on Systems, Man and Cybernetics—SMC'04* (Vol. 1, pp. 105-110), IEEE Press.
- Bushnell, N. (1996). Relationships between fun and the computer business. *Communications of the ACM*, 39(8), pp. 31-37.
- Cronin, J. (2004). Rural Africa joins mobile revolution, *BBC News Website* at <http://news.bbc.co.uk/1/hi/business/4036503.stm>
- Cupchik, G.C. (1994). Emotion in aesthetics: reactive and reflective models. *Poetics*, 23, pp. 177-188.
- Ekuan K. (1998). *The aesthetics of the Japanese lunchbox*. MIT Press.
- Hartson, H.R. (2003). Cognitive, physical, sensory, and functional affordances in interaction design. *Behaviour & Information Technology*, 22(5), pp. 315-338.
- Heilig, M.L. (1962). *Sensorama simulator*. US Patent no. 3,050,870.
- Japanese Aesthetics (2005). *Iki*. Website, <http://flickr.com/groups/iki/>
- JapanToday (2005). Website, <http://metropolis.japantoday.com/tokyo/500/tech.asp>
- Jordan, P.W. (1998). Human factors for pleasure in product use. *Applied Ergonomics*, 29(1), pp. 25-33.
- Karat, C-M., Karat, J., Vergo, J., Pinhanez, C., Riecken, D., Cofino, T. (2002). That's entertainment! Designing streaming multimedia web experiences. *International Journal of Human-Computer Interaction*, 14(3&4), pp. 369-384.
- Lavie, T., Tractinsky, N. (2004). Assessing dimensions of perceived visual aesthetics of web sites. *International Journal of Human-Computer Studies*, 60, pp. 269-298.

- Locher, P.J., Stappers, P.J., Overbeeke, K.C. (1998). The role of balance as an organizing design principle underlying adults' compositional strategies for creating visual displays. *Acta Psychologica*, 99, pp. 141-161.
- Maslow, A.H. (1970). *Motivation and Personality*, 2nd. ed., Harper & Row, USA.
- Matravers, D. (2003). The aesthetic experience. *The British Journal of Aesthetics*, 43(2), pp. 158-174.
- Millis, K. (2001). Making meaning brings pleasure: the influence of the titles on aesthetic experiences. *Emotion*, 1(3), pp. 320-329.
- Nakatsu, R. (1998). Nonverbal information recognition and its application to communications. In: Proc. *ACM International Conference on Multimedia: Face/Gesture Recognition and their Applications--MULTIMEDIA '98* (pp. 2-9), ACM Press.
- Nakatsu, R., Rauterberg, M., Vorderer, P. (2005). A new framework for entertainment computing: from passive to active experience. In: F. Kishino et al. (eds.), ICEC 2005, *Lecture Notes in Computer Science*, vol. 3711, pp. 1-12.
- Nakatsu, R., Tosa, N. (1997). Inter communication theatre—towards the realization of interactive movies. In: Proc. *IEEE International Conference on Multimedia Computing and Systems--ICMCS'97* (pp. 519-524), IEEE Computer Society.
- Overbeeke, K.C., Djajadiningrat, J.P., Hummels, C.C.M., Wensveen, S.A.G. (2002). Beauty in usability: forget about ease of use! In: W.S. Green and P.W. Jordan (eds.), *Pleasure with products: beyond usability* (pp. 9-18), Taylor & Francis.
- Overbeeke, K.C., Wensveen, S.A.G. (2003). From perception to experience, from affordances to irresistibles. In: Proc. *ACM International Conference on Designing Pleasurable Products and Interfaces--DPPI '03* (pp. 92-97), ACM Press.
- Rauterberg, M. (2004). Enjoyment and entertainment in East and West. In: M. Rauterberg (ed.), ICEC 2004, *Lecture Notes in Computer Science*, vol. 3166, pp. 176-181.
- Rauterberg, M., Steiger, P. (1996). Pattern recognition as a key technology for the next generation of user interfaces. In: Proc. *IEEE International Conference on Systems, Man and Cybernetics--SMC'96* (Vol. 4, pp. 2805-2810), IEEE Press.
- Rauterberg, M., Strohm, O., Kirsch, C. (1995). Benefits of user-oriented software development based on an iterative cyclic process model for simultaneous engineering. *International Journal of Industrial Ergonomics*, 16(4-6), pp. 391-410.
- Rauterberg, M., Szabo, K. (1995). A design concept for N-dimensional user interfaces. In: Proc. *International Conference INTERFACE to Real & Virtual Worlds* (pp. 467-477), Montpellier: EC2 & Cie.
- Salem, B., Rauterberg, M. (2004). Multiple user profile merging (MUPE): key challenges for environment awareness. In: P. Markopoulos et. al. (eds.), EUSAI 2004, *Lecture Notes in Computer Science*, vol. 3295, pp. 196-206.
- Sengers, P., Kaye, J., Boehner, K., Fairbank, J., Gay, G., Medynskiy, Y., Wyche, S. (2004). Culturally embedded computing. *Pervasive Computing*, 3(1), pp. 14-21.
- Servomaa, S. (2001). Aesthetics of the art of flowers: ikebana. In: G. Marchiano & R. Milani (eds.), Proc. *Intercontinental Conference 'Frontiers of Transculturality in Contemporary Aesthetics'* (pp. 367-377), Turin, Italy.
- Suzuki, D.T. (1959). *Zen and Japanese Culture*. Princeton University Press.
- Symbian (2005). Website, <http://www.symbian.com/images/library/n-gage-lo-res.jpg>
- Tosa, N., Matsuoka, S. (2003). Intuitive storytelling interaction: ZENetic computer. In: M. Rauterberg et al. (eds.), *INTERACT'03* (pp. 997-999), IFIP, IOS Press.
- Tosa, N., Nakatsu, R. (2000). Interactive art for Zen: 'unconscious flow'. In: Proc. *IEEE International Conference on Information Visualization--IV'00* (pp. 535-540), IEEE Computer Society.
- Weiser, M. (1991). The computer for the 21st century. *Scientific American*, 265(3), pp. 94-104.
- Yamamoto, Y. (1999). *An aesthetics of everyday life*. M.Sc. Thesis, University of Chicago, USA.