

On Human Aspects in Ambient Intelligence

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Abstract. This paper briefly outlines the scientific area that addresses Ambient Intelligence applications in which not only sensor data, but also knowledge from the human-directed sciences such as biomedical science, neuroscience, and psychological and social sciences is incorporated. This knowledge enables the environment to perform more in-depth, human-like analyses of the functioning of the observed humans, and to come up with better informed actions. It is discussed which ingredients are important to realise this view, and how frameworks can be developed to combine them to obtain the intended type of systems: reflective coupled human-environment systems. Finally, further perspectives are discussed for Ambient Intelligence applications based on these reflective coupled human-environment systems.

1 Introduction

Ambient Intelligence provides possibilities to contribute to more personal care; e.g., (Aarts, Harwig, Schuurmans, 2001; Aarts, Collier, Loenen, Ruyter, 2003; Riva, Vatalaro, Davide, Alcañiz, 2005). Acquisition of sensor information about humans and their functioning is an important factor, but without adequate knowledge for analysis of this information, the scope of such applications is limited. However, devices in the environment possessing such knowledge can show a more human-like understanding and base personal care on this understanding. For example, this may concern elderly people, patients depending on regular medicine usage, surveillance, penitentiary care, psychotherapeutic/selfhelp communities, but also, for example, humans in highly demanding tasks such as warfare officers, air traffic controllers, crisis and disaster managers, and humans in space missions; e.g., (Green, 2005; Itti and Koch, 2001).

Within human-directed scientific areas, such as cognitive science, psychology, neuroscience and biomedical sciences, models have been and are being developed for a variety of aspects of human functioning. If such models of human processes are represented in a formal and computational format, and incorporated in the human environment in devices that monitor the physical and mental state of the human, then such devices are able to perform a more in-depth analysis of the human's functioning. This can result in an environment that may more effectively affect the state of humans by undertaking in a knowledgeable manner actions that improve their wellbeing and performance. For example, the workspaces of naval officers may include systems that, among others, track their eye movements and characteristics of

incoming stimuli (e.g., airplanes on a radar screen), and use this information in a computational model that is able to estimate where their attention is focussed at. When it turns out that an officer neglects parts of a radar screen, such a system can either indicate this to the person, or arrange on the background that another person or computer system takes care of this neglected part. In applications of this type, an ambience is created that has a better understanding of humans, based on computationally formalised knowledge from the human-directed disciplines.

2 Multidisciplinarity: the Ingredients

The area as sketched is essentially multidisciplinary. It combines aspects of Ambient Intelligence with knowledge from human-directed disciplines such as psychology, social science, neuroscience and biomedical sciences. Further development will depend on cooperation between researchers from these disciplines or working on cross connections of Ambient Intelligence with the human-directed disciplines. The focus is on the use of knowledge from these disciplines in Ambient Intelligence applications, in order to take care in a more sophisticated manner of humans in their daily living in medical, psychological and social respects. For example, modellers in the psychological, neurological, social or biomedical disciplines interested in Ambient Intelligence as a high-potential application area for their models, can get inspiration for problem areas to be addressed for further developments in their disciplines. From the other side, researchers in Computer Science, and Artificial and Ambient Intelligence may become more aware of the possibilities to incorporate more substantial knowledge from the psychological, neurological, social and biomedical disciplines in Ambient Intelligence architectures and applications, and may offer problem specifications that can be addressed by the human-directed sciences.

In more detail, content from the domain of human-directed sciences, among others, can be taken from areas such as medical physiology, health sciences, neuroscience, cognitive psychology, clinical psychology, psychopathology, sociology, criminology, and exercise and sport sciences. From the domain of Artificial Intelligence, useful contributions can be found in areas such as agent modelling, knowledge and task modelling, and cognitive and social modelling and simulation. Finally, from the Computer Science domain, relevant areas are distributed systems, sensor systems, human-centred software engineering, user modelling, and human-computer interaction.

3 Frameworks to Combine the Ingredients

One of the challenges is to provide frameworks that cover the class of Ambient Intelligence applications showing human-like understanding and supporting behaviour. Here human-like understanding is defined as understanding in the sense of being able to analyse and estimate what is going on in the human's mind (a form of mindreading) and in his or her body (a form of bodyreading). Input for these processes are observed information about the human's state over time, and dynamic models for the human's physical and mental processes. For the mental side such a

dynamic model is sometimes called a Theory of Mind (e.g., Baron-Cohen, 1995; Dennett, 1987; Gärdenfors, 2003; Goldman, 2006) and may cover, for example, emotion, attention, intention, and belief. Similarly for the human's physical processes, such a model relates, for example, to skin conditions, heart rates, and levels of blood sugar, insulin, adrenalin, testosterone, serotonin, and specific medicines taken. Note that different types of models are needed: physiological, neurological, cognitive, emotional, social, as well as models of the physical and artificial environment.

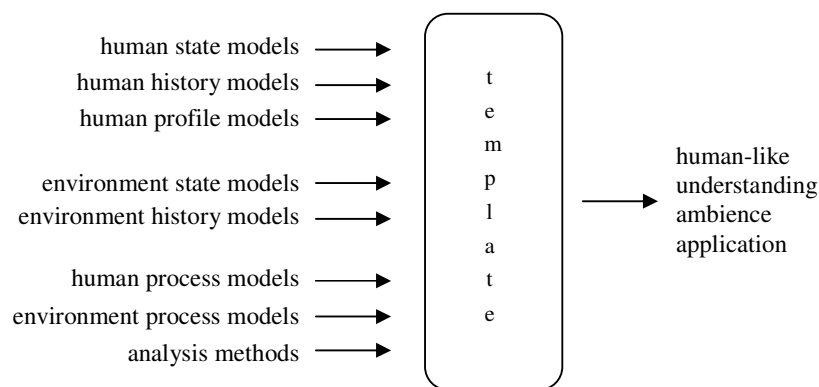


Figure 1 Framework to combine the ingredients

A framework can be used as a template for the specific class of Ambient Intelligence applications as described. The structure of such an ambient software and hardware design can be described in an agent-based manner at a conceptual design level and can be given generic facilities built in to represent the following (see also Figure 1):

- human state and history models
- environment state and history models
- profiles and characteristics models of humans
- ontologies and knowledge from biomedical, neurological, psychological and/or social disciplines
- dynamic process models about human functioning
- dynamic environment process models
- methods for analysis on the basis of such models

Examples of such analysis methods are voice and skin analysis with respect to emotional states, gesture analysis, heart rate analysis. The template can include slots

where the application-specific content can be filled to get an executable design for a working system. This specific content together with the generic methods to operate on it, provides a reflective coupled human-environment system, based on a tight cooperation between a human and an ambient system to show human-like understanding of humans and to react from this understanding in a knowledgeable manner.

4 Perspectives of Reflective Coupled Human-Environment Systems

Ambient Intelligence applications in general can be viewed as coupled human-environment systems, where ‘coupled’ means mutually interacting. For the specific type of applications considered here, however, the coupling takes two different forms; see also Figure 2.

- On the one hand the coupling takes place as interaction between human and environment, as in any Ambient Intelligence application:
 - the environment gets information generated by the human as input, and
 - the human gets information generated by the environment as input.
- In addition, coupling at a more deep, reflective level takes place due to the fact that
 - the environment has and maintains knowledge about the functioning of the human, the environment and their interaction, and
 - the human has and maintains knowledge about functioning of him or herself, the environment, and their interaction

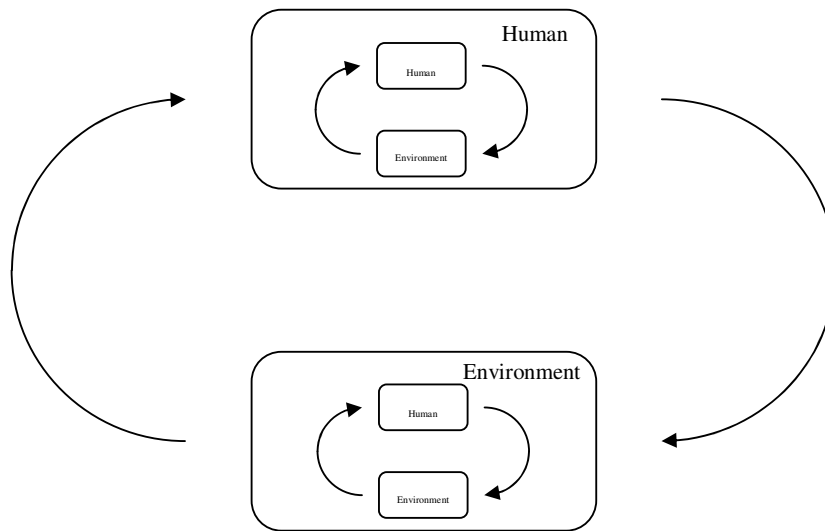


Figure 2 Reflective coupled human-environment systems

So, in such a more specific human-environment system, being coupled does not only mean that the human and its environment interact, but also that they have knowledge, understanding and awareness of each other, themselves and their interaction. This entails two types of awareness:

- *Human awareness:* awareness by the human about the human and environmental processes and their interaction
- *Technological awareness:* awareness by the environment about the human and environmental processes and their interaction

By(human and technological) learning, adaptation and development processes for both the human and the environment these awarenesses can also grow over time.

Such reflective coupled human-environment systems can have a positive impact at different aggregation levels, from individual via an organisation within society to the society as a whole:

- *Individual level*
 - more effective functioning
 - stimulating healthy functioning and preventing health problems to occur
 - support of learning and development
- *Organisation level*
 - efficient functioning organisation by wellfunctioning members
 - learning and adaptation of the organisation
- *Society level:*
 - limiting costs for illness and inability to work
 - efficient management of environment

Some more specific examples of today's societal challenges, to which reflective coupled human-environment systems can contribute, are elderly care, health management, crime and security.

5 Conclusion

The scientific area that addresses Ambient Intelligence applications in which knowledge from the human-directed sciences is incorporated, has a high potential to provide nontrivial Ambient Intelligence applications based on human-like understanding. Such understanding can result in better informed actions and will feel more natural for humans. Important additional ingredients to realise this view are provided by areas in Computer Science, Artificial Intelligence and Cognitive Science; among others: agent modelling, knowledge and task modelling, user modelling, and cognitive modelling. Furthermore integrative frameworks can be developed to

combine the ingredients. The resulting human-environment systems are coupled not only by their mutual interaction, but also in a reflective manner in the sense that both the human and the ambient system have and/or develop a model of the interactive processes of the human and the environment. These reflective coupled human-environment systems are an interesting type of systems to be studied scientifically, and provide a solid foundation for human-like Ambient Intelligence applications with significant benefits for individuals, organisations, and the society as a whole.

Acknowledgements

The author is grateful to a number of colleagues that in discussions have deepened insight in the area, among whom Tibor Bosse, Frank van Harmelen, Mark Hoogendoorn, Johan Hoorn, Michel Klein, Peter-Paul van Maanen, Andre Spijkervet, Maarten van Steen, Gerrit van der Veer, and Chris Verhoef.

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