

# Ambient Intelligence

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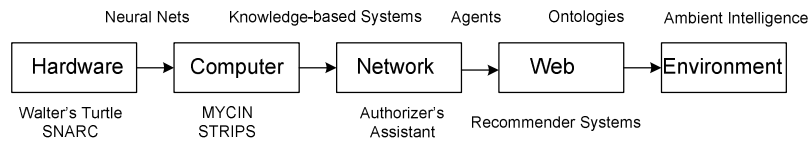
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**Abstract.** Ambient Intelligence (AmI) deals with a new world where computing devices are spread everywhere (ubiquity), allowing the human being to interact in physical world environments in an intelligent and unobtrusive way. These environments should be aware of the needs of people, customizing requirements and forecasting behaviors. AmI environments may be so diverse, such as homes, offices, meeting rooms, schools, hospitals, control centers, transports, touristic attractions, stores, sport installations, music devices, etc. In the aims of Ambient Intelligence, research envisages to include more intelligence in the AmI environments, allowing a better support to the human being and the access to the essential knowledge to make better decisions when inter-acting with these environments. This paper can be seen as a State of the Art of Ambient Intelligence, according to an Artificial Intelligence (AI) perspective. We will define Ambient Intelligence; refer some of their prototype and systems; and to analyze how the main Artificial Intelligence areas can be applied.

## I. Introduction

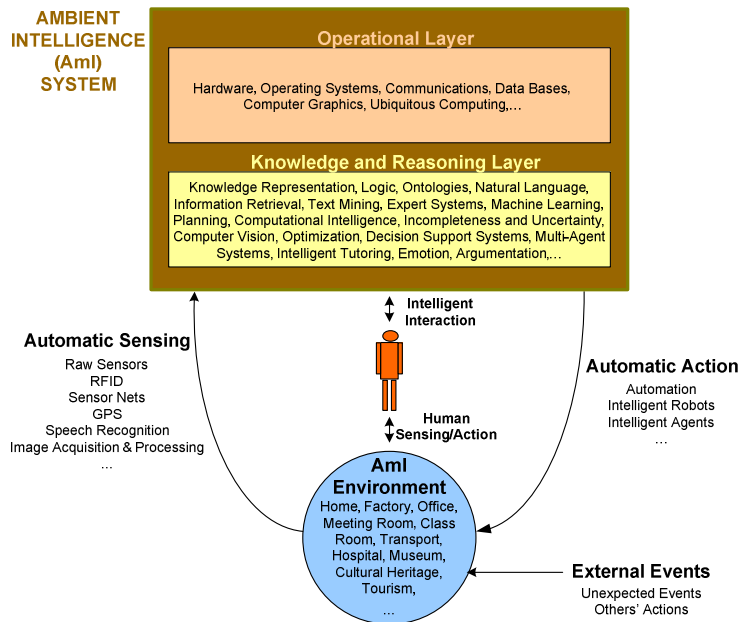
The European Commission's IST Advisory Group (ISTAG) has introduced the concept of Ambient Intelligence (AmI) [1,2]. ISTAG believes that it is necessary to take a holistic view of Ambient Intelligence, considering not just the technology, but the whole of the innovation supply-chain from science to end-user, and also the various features of the academic, industrial and administrative environment that facilitate or hinder realization of the AmI vision [3]. Due to the great amount of technologies involved in the Ambient Intelligence concept we may find several works that appeared even before the ISTAG vision pointing in the direction of Ambient Intelligence trends. Other concepts have some overlapping with Ambient Intelligence, namely Ubiquitous Computing, Pervasive Computing, Context Awareness and Embedded Systems. Here we will center our analysis in the relation between Artificial Intelligence (AI) and Ambient Intelligence.



**Figure 1.** AI evolution

Figure 1 shows the AI evolution over the time. In the beginning, AI was applied to hardware, like the SNARC system proposed by Minsky and Edmonds. Neural Nets is an example of technology applied on these systems. The MYCIN Knowledge-based System is a good example of a phase where AI was more centered on computers. The following phase was more centered on the networks; the American Express Authorizer’s Assistant is a landmark work of this phase. During the 90’s the Web boom originated many recommender systems using Intelligent Agents and Ontologies. The question is “What is the next step?”. The current trends are pointing to the inclusion of intelligence in the own human being environments. Ambient Intelligence is the solution for this purpose.

Today, many systems use Ambient Intelligence like a buzzword, and most of times no intelligence is involved. Many researchers are building AmI systems without AI, putting the effort just in operational technologies (sensors, actuators, and communications). However it is not expected a great success for these systems. AmI results from the combination of AI and many operational technologies. It is not expected success if we build AmI systems without operational technologies, just with AI. But it is a tremendous mistake to build these systems without AI.



**Figure 2** Ambient Intelligence vision from AI perspective

Figure 2 shows our vision of Ambient Intelligence, oriented for the correct importance of AI. Our AmI environment may be so diverse, like our home, our car, a museum, an office. Sensing is used to capture information of this world, by the human being using their senses or by automatic systems like ultrasonic devices, cameras, and microphones. Action on this world is possible by means of the human being decisions and actions or by automatic systems like robots and agents. Ambient Intelligence systems are inserted in the environment, receiving information from sensing devices or other information sources, interact with the user, are able to perform elaborated reasoning processes, and may order actions on the environment. The human being is also able to perform sensing and action on the environment, but she/he is not the only one able to act on the environment. Besides automatic systems, other persons may change the environment state, and unexpected events may occur. Ambient Intelligence Systems have operational technologies to support them, like sensors, actuators, communications, and ubiquitous computing. On the other hand, if intelligence is not a buzzword in the AmI concept, these systems must be supported in some knowledge or reasoning-based technologies. Natural Language, Expert Systems, Image Understanding, Ontologies, and Emotion are just some of the technologies that may be present in AmI systems.

## **II Ambient Intelligence Prototypes and Systems**

Here we will analyze some examples of Ambient Intelligence prototypes and systems, divided by the area of application.

### **2.1 AmI at Home**

Domotics is a consolidated area of activity. After the first experiences using Domotics at homes there was a trend to refer the Intelligent Home concept. However, Domotics is too centred in the automation, giving to the user the capability to control the house devices from everywhere. We are still far from the real Ambient Intelligence in homes, at least at the commercial level.

Several organizations are doing extended experiences to achieve the Intelligent Home concept. Some examples are HomeLab from Philips, MIT House\_n, Georgia Tech Aware Home, Microsoft Concept Home, and e2 Home from Electrolux and Ericsson.

### **2.2 AmI in Vehicles and Transports**

Since the first experiences with NAVLAB 1 [4], Carnegie Mellon University has developed several prototypes for Autonomous Vehicle Driving and Assistance. The last one, NAVLAB 11, is an autonomous Jeep. Most of the car industry companies are doing research in the area of Intelligent Vehicles for several tasks like car parking assistance or pre-collision detection.

Another example of AmI application is related with Transports, namely in connection with Intelligent Transportation Systems (ITS). The ITS Joint Program of the US

Department of Transportation identified several areas of applications, namely: arterial management; freeway management; transit management; incident management; emergence management; electronic payment; traveler information; information management; crash prevention and safety; roadway operations and management; road weather management; commercial vehicle operations; and intermodal freight. In all these application areas Ambient Intelligence can be used.

### **2.3 AmI in Elderly and Health Care**

Several studies point to the aging of population during the next decades. While being a good result of increasing of life expectation, this also implies some problems. The percentage of population with health problems will increase and it will be very difficult to Hospitals to maintain all patients. Our society is faced with the responsibility to care for these people in the best possible social and economical ways. So, there is a clear interest to create Ambient Intelligence devices and environments allowing the patients to be followed in their own homes or during their day-by-day life.

The medical control support devices may be embedded in clothes, like T-shirts, collecting vital-sign information from sensors (blood pressure, temperature, etc). Patients will be monitored at long distance. The surrounding environment, for example the patient home, may be aware of the results from the clinical data and even perform emergency calls to order an ambulance service.

For instance, we may refer the IST Vivago® system (IST International Security Technology Oy, Helsinki, Finland), an active social alarm system, which combines intelligent social alarms with continuous remote monitoring of the user's activity profile [5].

### **2.4 AmI in Tourism and Cultural Heritage**

Tourism and Cultural Heritage are good application areas for Ambient Intelligence. Tourism is a growing industry. In the past tourists were satisfied with pre-defined tours, equal for all the people. However there is a trend in the customization and the same tour can be conceived to adapt to tourists according their preferences.

Immersive tour post is an example of such experience [6]. MEGA is an user-friendly virtual-guide to assist visitors in the Parco Archeologico della Valle del Temple in Agrigento, an archaeological area with ancient Greek temples in Agrigento, located in Sicily, Italy [7].

### **2.5 AmI at Work**

The human being spends considerable time in working places like offices, meeting rooms, manufacturing plants, control centres, etc.

SPARSE is a project initially created for helping Power Systems Control Centre Operators in the diagnosis and restoration of incidents [8]. It is a good example of context awareness since the developed system is aware of the on-going situation, acting in different ways according the normal or critical situation of the power system. This system is evolving for an Ambient Intelligence framework applied to Control Centres.

Decision Making is one of the most important activities of the human being. Nowadays decisions imply to consider many different points of view, so decisions are commonly taken by formal or informal groups of persons. Groups exchange ideas or engage in a process of argumentation and counter-argumentation, negotiate, cooperate, collaborate or even discuss techniques and/or methodologies for problem solving. Group Decision Making is a social activity in which the discussion and results consider a combination of rational and emotional aspects. ArgEmotionAgents is a project in the area of the application of Ambient Intelligence in the group argumentation and decision support considering emotional aspects and running in the Laboratory of Ambient Intelligence for Decision Support (LAID) [9], a kind of Intelligent Decision Room. This work has also a part involving ubiquity support.

## **2.6 AmI in Sports**

Sports involve high-level athletes and many more practitioners for hobby of free-time occupancy. Many sports are done without any help of the associated devices, opening here a clear opportunity for Ambient Intelligence to create sports assistance devices and environments.

FlyMaster NAV+ is a free-flight on-board pilot Assistant (e.g. gliding, hangliding, paragliding), using the FlyMaster F1 module with access to GPS and sensorial information. FlyMaster Avionics S.A., a spin-off, was created to commercialize these products.

## **III Conclusions**

In this introduction paper of this special issue dedicated to the topic of Ambient Intelligence we presented our vision of Ambient Intelligence. According to this vision Ambient Intelligence environments are the next places where AI community should centre the attention (figure 1). AI community should be aware of the incorrect use of “intelligence” word in some developed systems. We must claim that no Ambient Intelligence will be achieved without AI. Figure 2 can be seen as a position figure of the AI on Ambient Intelligence. The other papers of this special issue will show you some of the work being done by AI community in Ambient Intelligence. Real Ambient Intelligence prototypes and systems involving AI will appear in this special issue. AI methods and techniques like multi-agent systems, case-based planning, fuzzy systems, logic programming, hidden Markov model, and ontologies are used in these works. The environments differ from hospitals, geriatric residences, home and work, cultural heritage places, and tourism.

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