INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

# DELIVERABLE 4.1.1

# STATE OF THE ART

# LIFEWEAR, MOBILIZED LIFESTYLE WITH WEARABLES

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# 1 AMBIENT INTELLIGENCE

## 1.1 Introduction & definition

Advances in the miniaturization of electronics are allowing computing devices with various capabilities and interfaces to become part of our daily life. Sensors, actuators, and processing units can now be purchased at very affordable prices. This technology can be networked and used with the coordination of highly intelligent software to understand the events and relevant context of a specific environment and to take sensible decisions in real-time or *a posteriori*.

It is particularly interesting to contrast this time in history when accomplishing Weiser's aims sounds plausible with the situation five decades ago when computers had the size of a room and the idea of a computer being camouflaged with any environment was an unimaginable notion. Today different appliances have successfully become integrated to our daily life surroundings to such an extent that we use them without consciously thinking about them. Computing devices have transitioned in this past half a century from big mainframes to small chips that can be embedded in a variety of places. This has allowed various industries to silently distribute computing devices all around us, often without us even noticing, both in public spaces and in our more private surroundings. Now washing machines, heating systems and even toys come equipped with some capability for autonomous decision making. Automotive industry has become increasingly interested in embedding sensing mechanisms that allow the car to make decisions for a safer and less expensive journey, and as a result cars now have dozens of sensor and actuator systems that make decisions on behalf of or to assist the driver. Public spaces have become increasingly occupied with tracking devices which enable a range of applications such as sensing shoplifted object and crowd behaviour monitoring in a shopping mall.

Whether it is our home anticipating when the lights should be turned on and off, when to wake us up or order our favourite food from the supermarket, a transport station facilitating commuting, or a hospital room helping to care for a patient, there are strong reasons to believe that our lives are going to be transformed in the next decades by the introduction of a wide range of devices which will equip many diverse environments with computing power.

These computing devices will have to be coordinated by intelligent systems that integrate the resources available to provide an "intelligent environment". This confluence of topics has led to the introduction of the area of "Ambient Intelligence" (AmI):

"A digital environment that proactively, but sensibly, supports people in their daily lives." [Augusto (2007)]

Ambient Intelligence started to be used as a term to describe this type of developments about a decade ago (see for example [Zelkha(1998), Aarts and Appelo(1999), IST Advisory Group(2001), Aarts et al(2002)]) and it has now been adopted as a term to refer to a multidisciplinary area which embraces a variety of pre-existing fields of computer science as well as engineering, see first figure. Given the diversity of potential applications this relationship naturally extends to other areas of science like education, health and social care, entertainment, sports, transportation, etc.

Whilst AmI nourishes from all those areas, it should not be confused with any of those in particular. Networks, sensors, human-computer interfaces, pervasive computing and Artificial Intelligence (here we also include robotics and multi-agent systems) are all relevant but none of them conceptually fully covers AmI. It is AmI which brings together all these resources as well as many other areas to provide flexible and intelligent services to users acting in their environments.

By Ambient Intelligence we refer to the mechanisms that rule the behaviour of the environment: The definition of Ambient Intelligence given above includes the need for a "sensible" system, and this means a system with intelligence. The definition reflects an analogy with how a trained assistant, e.g. a nurse, typically behaves. The assistant will help when needed but will restrain to intervene except when necessary.

Being sensible demands recognizing the user, learning or knowing her/his preferences, and the capability to exhibit empathy with or react to the user's mood and the prevailing situation, i.e., it implicitly requires for the system to be sensitive.

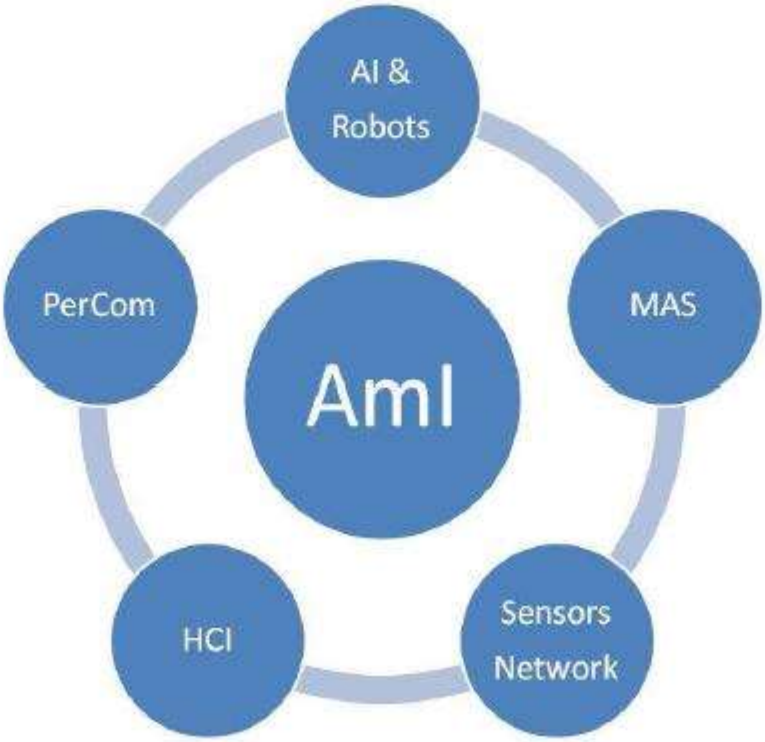


**Fig. 1. Relationship between AmI and several scientific areas.**

An important aspect of AmI has to do with interactivity. On the one hand there is a motivation to reduce *explicit* human-computer interaction (HCI) as the system is supposed to use its intelligence to infer the situations and user needs from the observed activities, as if a passive human assistant were observing the activities unfold with the expectation to help when (and only if) required. Systems are expected to provide situation-aware information (I-want-here-now) through natural interfaces. On the other hand, a diversity of users may need or voluntarily seek direct interaction with the system to indicate preferences, needs, etc.

HCI has been an important area of computer science since the inception of computing as an area of study and development. Today, with so many gadgets incorporating computing power of some sort, HCI continues to thrive as an important AmI topic.

It is also worthwhile to note that the concept of AmI is closely related to the "service science"[Spohrer et al(2007)] in the sense that the objective is to offer proper services to users. It may not be of interest to a user what kind of sensors are embedded in the environment or what type of middleware architecture is deployed to connect them. Only the services given to the user matter to them. Therefore, the main thrust of research in AmI should be integration of existing technologies rather than development of each elemental device.

Within the notion of the service science, it is important to consider the implications of user evaluation in a "service-evaluation-research" loop (Figure 2). As part of their investigation, AmI researchers should assess efforts to setting up working intelligent environments in which users conduct their normal activities. As the system is distributed in the environment, users only notice services they receive. The researchers then observe the interaction and (re-)evaluate the system. The result of the evaluation may lead to identifying new services, new viewpoints or even new evaluation criteria. Then all of the findings can be fed back to new research and development.


**Fig. 2. The loop between R&D, service, and evaluation.**

## 1.2 Current and past projects

In 2007, AMIE (Ambient Intelligence for the Elderly) project has developed an intelligent Information and communications technologies (ICT) based system offering elderly people a new way of obtaining advice on their health and wellbeing while monitoring their status and daily habits to help them overcome isolation and loneliness and enabling them to stay as long as possible in their own homes.

During 2008-2011, OSAmI-Commons (Open Source Ambient Intelligence Commons) project has developed a universal networking platform enabling reuse of software components across vertical application domains. This is crucial when tackling urgent societal challenges such as energy sustainability or the ever-growing care costs for an aging population. This software ecosystem will help address such problems efficiently by increasing the level of innovation and allowing development of more complex solutions and applications with less effort. The open modular platform can be used across many sectors and has been trialled and exploited for applications in ambient assisted living, energy-sustainable homes, telematics-based city services, smart homes, software development tools and edutainment.

Currnetly, The ViCoMo project is developing advanced video-interpretation algorithms to enhance images acquired with multiple camera systems. By modelling the context in which such systems are used, ViCoMo will significantly improve the intelligence of visual systems and enable recognition of the behaviour of persons, objects and events in a 3D view. The project will enable advanced content and contextbased applications in surveillance and security, and transport/logistics with spin-offs in the consumer and multimedia domain.

## 1.3 Lifewear innovation

In all Lifewear scenarios, ambient intelligence is used to capture data from various sensors and understand the environment of the user. All this data will be combined, processed and used to take decisions that will provide the user useful information in order to give precise instructions to using a interface easy to understand.

# 2 AMBIENT ASSISTED LIVING

## 2.1 Introduction & definition

Ambient Assisted Living (AAL) applications provide an immense potential for enhancing medical homecare, especially in the light of an increased importance of early detection and preventive care.

Remote patient monitoring does not only enable effective therapy support and the detection of abnormal conditions in an early state, it also proofed to contribute to a significant reduction of hospitalization and an increased success in long-term therapies. The potential of technology-supported homecare was empirically confirmed for a variety of applications, including self-monitoring and dietary education of diabetic patients, remote patient monitoring and counseling, remote counseling for patients with congestive heart failures, or remote cardiac arrhythmia monitoring.

The diversity of Ambient Assisted Living applications is matched by a broad variety of implementation approaches. Looking at state-of-the-art prototypes shows that Ambient Assisted Living services can be successfully realized through a variety of different implementation approaches and device types. This paper takes a closer look at existing work in this field and provides a structured overview over selected applications and systems. Hence, this paper is not a research paper in the traditional sense. Instead, it has to be seen as scholarly article meant to provide a comprehensive overview over state-of-the-art implementation concepts in the field of Ambient Assisted Living. With respect to existing AAL prototypes and research demonstrators, it seems to be helpful to distinguish among the following five types of devices: mobile devices, smart artefacts, wearables, implants, and robots. Similar classification schemes are proposed by Orwat and Muras. The following sections provide a short description as well as exemplary systems for each device category.

### Mobile Devices

Mobile devices are probably the simplest form of providing medical assistance for elderly users. They represent dedicated medical devices and, in most cases, can be easily recognized as such. Mobile medical appliances are designed for a variety of different illnesses and usually provide monitoring functions combined with patient-specific medical support. For example, the SenseWear armband is a wearable body monitor that was designed for both normal subjects and patients with chronic obstructive pulmonary disease and allows capturing body movement and energy expenditure. A similar wrist-worn device called Röcker, C. (2011). Designing Ambient Assisted Living Applications: An Overview of State-of-the-Art Implementation Concepts. In: X. Chunxiao (Ed.): Modeling, Simulation and Control, Proceedings of the International Conference on Information and Digital Engineering (ICIDE 2011), September 16-18, Singapore, pp. 167 - 172.HealthWear is available from BodyMedia. The system captures temperature gradients from skin to environment, mechanical activity and bioimpedance of the skin. Other applications are embedded into existing communication devices. For example, Vitaphone is a mobile phone with integrated heart monitoring functions, and Dr. Feelgood is a combination of a PDA and mobile phone, which measures various physiological functions. While these systems are usually designed to provide dedicated functionalities, Youngbum and Myoungho developed a multi-functional system, which enable users to combine different modules. These modules include functionalities like fall detection, electrocardiograms, or non-invasive measurement of blood sugar and oxygen saturation.

### Smart Artefacts

The notion of Smart Artefacts describes technology-enhanced everyday objects, which are equipped with sensors, memory and communication capabilities. Hence, they are able to capture information about their surroundings, communicate with each other and react according to previously defined rules. Through their capability to interact with humans directly, they can help users to accomplish their tasks in new, intuitive ways. In contrast to mobile medical devices, the additional medical functionalities of smart artefacts are usually not visible to outsiders. The Smart Pillow, for example, is an electronic monitoring devices in form of a traditional pillow, which checks the user's basic vital parameters, such as respiration, pulse and body temperature, and in the case of an emergency or illness immediately notifies medical personnel. The Smart Sofa is a sensor-enhanced couch that is able to identify individuals sitting on it and provides personalized services based on this information. Smart Dishes is a set of intelligent kitchen devices developed at the Massachusetts Institute of Technology, including, e.g., a smart pan that can determine whether it is too hot to be touched, a spoon that provides feedback about the temperature and viscosity of food, and a kettle that informs users how much longer they have to wait for their tea. Other examples of smart household objects include, for example, interactive tablecloths or smart coffee cups.

### Wearables

Instead of an additional mobile device that has to be intentionally taken when users leave their stationary computer, the concept of Wearable Computing envisions computers to be an integral part of our everyday clothing. The goal is to have an always-on and networked computational artefact that assists mobile users in a wide range of everyday situations. With respect to wearable health technology, two main streams of research became prevalent over the last years: smart jewelry and smart clothes.

A notable example for smart jewelry is a series of Smart Ring devices developed by Asada. The rings are wearable like traditional jewelry and equipped with saturation sensors, an energy supply and an RF link. With the Gesture Pendant, Starner developed a wearable control device, which recognizes pre-defined gestures and corresponding control tasks. A variety of other examples for smart jewelry were created by different designers like, e.g., Kikin-Gil, who developed smart jewelry for supporting non-verbal communication within small teenage groups.

Another popular approach is to integrate medical monitoring devices into watches. Some devices are already commercially available, like, e.g., the Actiwatch from Cambridge Neurotechnology. The Actiwatchdevice is equipped with a miniature accelerometer that measures the general activity of its wearer. In combination with additional sensors the functionality of the watch could be extended to monitoring insomnia, mood, energy expenditure or the detection of periodic limb movement during sleep. There are several other examples of wristwatches offering additional medical functionalities, including cystic fibrosis testing, glucose measurement, blood oxygen monitoring, or emergency calls.

One of the first examples of smart clothes was the Smart Shirt developed at the Georgia Institute of Technology. Different types of sensors are integrated into the design of the Smart Shirt, which allow monitoring a variety of vital parameters, including heart rate, electrocardiogram (ECG), respiration, temperature, or vital functions. A further example for a wearable physiological monitoring system is the Smart Vest. The system allows monitoring multiple physiological parameters such as ECG, heart rate, blood pressure, or body temperature, and transmits the captured physiological data along with the geo-location of its wearer to remote monitoring stations. Some systems are already available as commercial products, like the LifeShirt from Vivometrics, which includes a respiratory inductive plethysmography system to monitor various cardio respiratory parameters. But medical technology is also integrated into other pieces of clothing. The Actibelt, for example, functions like a traditional textile belt, but has a threedimensional accelerometer integrated in its buckle. The sensor captures the type and intensity ofmovement and allows monitoring the wearer's physical activity outside institutional settings over an extended period of time. Other examples of smart clothes include active hip protectors, smart shoes, intelligent knee sleeves or smart baby bodies.

### Implants

Dental implants are probably the most widely accepted form of medical implants. In most cases, sensor and telemetry systems are integrated into an artificial tooth or crown invisibly located inside the patient's mouth. One of the first systems was developed within the European project Saliwell and aimed at patients with insufficient saliva production. The prototype of a dental implant is based on an electronic saliva stimulating device, which constantly monitors oral parameters and automatically restores salivation without additional medication. Other EU-funded research projects working on related topics are the NanoTIMER project, which develops nano technology for mechanical-electrical resonators, or the HEALTHY AIMS project, which aims at the development of nano-scale materials, sensors and microsystems for medical implants. A further example for a dental implant is the IntelliDrug system, an automated medication device implemented in a denture.

### Robots

The use of robotic systems for elderly care seems to be debatable and appears to be driven by a strong cultural component. While there are numerous companies and research institutes working on care robots in Asia, especially Japan and Korea, the research activities in this field in Europe and the United States are almost non-existent. In general, medical robot systems are used for two types of applications. First, for compensating a handicap of a user and second, for supporting users in carrying out daily activities and tasks. One of the first robot systems offering medical home care was KARES I, a wheelchair-based rehabilitation robot. The system offered four basic services for supporting severely handicapped patients in home environments. The functionality of KARES I was extended in the second version (KARES II), which now supports twelve predefined tasks. DO-U-MI is another nursing robot system especially designed for elderly and disabled people, which assists users in moving independently in indoor environments. The system provides an easy-to-use interface and is able to detect and localize human faces and sound sources in order to position itself for services. Jung developed an intelligent bed robot system that actively helps disabled patients to move within their beds by monitoring their postures and motions and supporting the body movement with a robotic manipulator.

## 2.2 Current and past projects

Between 2004 – 2006 The ITEA AMEC project had developed. The ITEA AMEC project envisages a paradigm shift in which everyday products will become interconnected, building embedded, intelligent and interactive systems together with seamless interfaces to back-end Internet services in which the user takes a central place. From a technological point of view, the project concerns itself with enabling convergence and interoperability between traditional consumer electronics networks, the personal computer (PC) and the Internet, emerging domotic networks, and the fast moving space of mobile networks and devices. From an end-user point of view, the AMEC project also concerns itself with people’s emerging behaviours, with real, latent and unmet needs as well as people’s everyday frustrations and concerns about technology, and their aspirations for a better lifestyle.

## 2.3 Lifewear innovation

LifeWear works are focused on Firefighting stress thermal detection T-shirt and other devices aims to improve the user quality life.

# 3 CONTEXT CREATION AND MAINTENANCE

## 3.1 Introduction & definition

Context can be described as any information that can be utilized to characterize the situation of one entity (a person, a place, or an object) that is considered relevant in the interaction between a user and an application. The main role of context in Lifewear project is to provide humans a much greater control over the actions an devices. Context permits to define which knowledge should be considered, what are its conditions of activation, the limits of validity and when to use an application at a given time. This is especially important for the building and the use of large and reliable knowledge systems. Contexts act like adjustable filters for giving the right meaning in the current context and to present the minimal number of information pieces and essential functions that are necessary to develop the task at hand. For instance, the concept of water is viewed differently by a thirsty person, the plumber, the chemist, and the painter.

We have five important aspects to consider, known as the theory of the five W's: Who, Where, When, What and Why. This theory used in multiple areas such as journalism and psychology, among others. In our case we identified the profile of the user and their situation, the relative location of the user within a building, the relative time which is the task that is doing or want to perform and last and most important and complex, the purpose or goal of the user. [1]

## 3.2 Current and past projects

Ubiquitous computing projects, ambient intelligence an artificial intelligence projects are projects based in the creation of context and maintenance, in this sense this document is a showcase of this issues.

In 1998, the board of management of Philips commissioned a series of presentations and internal workshops, organized by Eli Zelkha and Brian Epstein of Palo Alto Ventures (who, with Simon Birrell, coined the name 'Ambient Intelligence') to investigate different scenarios that would transform the high-volume consumer electronic industry from the current “fragmented with features” world into a world in 2020 where user-friendly devices support ubiquitous information, communication and entertainment. While developing the Ambient Intelligence concept, Palo Alto Ventures created the keynote address for Roel Pieper of Philips for the Digital Living Room Conference, 1998. The group included Eli Zelkha, Brian Epstein, Simon Birrell, Doug Randall, and Clark Dodsworth. In the years after, these developments grew more mature. In 1999, Philips joined the Oxygen alliance, an international consortium of industrial partners within the context of the MIT Oxygen project,[1] aimed at developing technology for the computer of the 21st century. In 2000, plans were made to construct a feasibility and usability facility dedicated to Ambient Intelligence. This HomeLab officially opened on 24 April 2002.

Along with the development of the vision at Philips, a number of parallel initiatives started to explore ambient intelligence in more detail. Following the advice of the Information Society and Technology Advisory Group (ISTAG), the European Commission used the vision for the launch of their sixth framework (FP6) in Information, Society and Technology (IST), with a subsidiary budget of 3.7 billion euros. The European Commission played a crucial role in the further development of the AmI vision. As a result of many initiatives the AmI vision gained traction. During the past few years several major initiatives have been started. Fraunhofer Society started several activities in a variety of domains including multimedia, microsystems design and augmented spaces. MIT started an Ambient Intelligence research group at their Media Lab.[3] Several more research projects started in a variety of countries such as USA, Canada, Spain, France and the Netherlands. In 2004, the first European symposium on Ambient Intelligence (EUSAI) was held and many other conferences have been held that address special topics in AmI.

### 3.3 LifeWear Innovation

In the firefighting area, it is necessary to detect a thermal stress situation to prevent the fireman from falling down in the middle of a fire situation avoiding his death. For this situation it is planned to develop a wearable device like a polo shirt. The polo shirt will have sensors to collect all the vital sign. These vital signs will be sent to the electronic board that will calculate the thermal stress level. The result of these calculations will be sent to a device (watch or phone) where the fireman could check his own status and if the value given it starts to be dangerous, the device will warn the user through a sound or vibration sign. These values will be also sending to the Brigade manager to check from the lorry the status of each fireman and if some of them are in a thermal stress situation, give the order to leave the service. This situation represents a Lifewear innovation solution into new criteria, the creation context and maintenance.

# 4 LOCATION-AWARE SERVICES

## 4.1 Introduction & definition

Location-Aware telecommunication Services (LASs), also known as location-based or location-related services, are applications that integrate location or position data with other information in order to provide value-added services. Typical examples are car navigation systems, tourist tour planning, and mobile marketing, and so on. LASs are a subset of context-aware services, i.e., services able to automatically adapt their behavior depending on the context of specific targets. It is important to highlight that, in such a context, targets not always correspond to users but they can be viewed as general entities that must be "located" (e.g., goods, vehicles, people).

## 4.2 Current and past projects

LASs have a long history. In fact, a well-known navigation device is the magnetic compass and the first vehicle navigation system dates back to the invention of the south pointing carriage in China around 2600 BC. In recent years, the Global Positioning System (GPS), conceived for military purposes by the Department of Defense of the U.S.A in 1970s and made freely available in 1980s, gives to the industries the opportunities to create new devices and services based on position or location data. GPS reaches a high accuracy level and it is able to localize targets in a range of few meters. However, modern interest in LASs started in 1990s with the introduction of mobile phone technology. Since then, mobile network operators were widely deployed in Europe, Asia and U.S.A., and a new cell-id technology was implemented able to localize users according to their position in the cellular phone network.

Cell-id technology offers low accuracy levels ranging between 100 meters to 3 kilometers depending on the target physical position (either urban or rural area). However, the significant diffusion of cell phones with a great computing power, a high-resolution screen and a fast data connection has enabled the LAS entrance into the service market. Without doubt next generation devices will integrate also GPS features, increasing localization precision and enhancing the spread of more and more sophisticated LASs.

A widely accepted definition of LAS is not available in the existing literature. The GSM association, a consortium of 600 GSM network operators, presented some examples of possible LASs: to show the location of a target on a map, to activate event-triggered tasks when a target enter or leaves a predefined location etc. The 3rd Generation

Partnership Project (3GPP), a federation of many international standardization authorities, distinguishes between LAS and location services. For 3GPP, location services deal only with the determination of the position of a target. Then, a location service has not to process location data. The position data are provided to other entities that finally provide LASs. LASs need always a location service to carry out their functions, therefore LASs and location services mostly appear in conjunction. In the following, we will not distinguish between location and location-aware services and we will use the term LAS interchangeably.

To describe the LAS provisioning, an early study about the concept of location is needed. In everyday life the term "location" is much diffused, but its meaning is not univocally defined leading to several characterizations. The word location typically refers to *physical location*, that is the position of a person, an object or, in general, a target in the real world. It is possible to identify three different physical location categories: *spatial location*, *descriptive location* and *network location*. The term *spatial location* is related to a position in the Euclidean space. Each location can be represented by a point in a (two or three)-dimensional space and identified by a vector of real numbers. Several equivalent representations can be obtained by changing both the coordinate system (e.g., Cartesian or Spherical coordinates) and the reference point.

While electronic devices and in general computer and telecommunication systems work well with numeric values, people do not like such numeric representation. In order to simplify the human communication, the social communities name geographical objects using conventional identifiers. *Descriptive location* then comes to be a common concept in the social life. Rooms, buildings, roads, cities, territories are identified by names. It is more probably to say “See you at Colosseo” instead of “See you at (41°53'N, 12°29'E)”. The descriptive location provides less accurate position identification with respect to the spatial location. In fact, one descriptive locator can be mapped onto more spatial locators.

With the spread of networking infrastructure such as Internet, GSM, GPRS, UMTS etc., the concept of *network location* came to light. Since various types of communication networks can be developed, the network location can assume different meanings. For example, in a cellular phone system, such as the GSM, the location could be the cell a terminal is attached to, while, in the Internet, the location could be the IP subnet address of the LAN the user is part of.LASs could be based on all categories previously discussed, and they must be able to map the different categories to make location information meaningful for all entities involved in the service provision. The mapping between the different categories and the translation from a representation to another are carried out by specific systems generally named Geographic Information Systems (GISs) that will be discussed later. Since 2000 the growth of the Internet community has lead to a new way of looking at the world. In analogy to the virtual reality, the *virtual location* came close to the physical location. From the virtual point of view, a location could be interpreted as a web site, a chat room or a mailing list. It is not easy to establish a rigorous mapping between virtual and physical positions. Furthermore, the two concepts of real and virtual are sometimes merged (e.g., in applications such as role playing games).

Currently, LASs deal only with physical location, while the management of interaction between real and virtual world mainly concerns the application developers. However, the diffusion of virtual applications is going to grow in the near future calling for a careful management of such issues.

**Design Issues of Location-aware Service Provisioning.**

Location-aware scenarios comprise a very great set of applications. Each of these has different characteristics and requires different services. A well-designed location-aware architecture must offer different services for different applications. Thus, it is mandatory to describe the typical scenarios classifying the location-aware applications and the requirements they impose on the LASs design, identifying the actors involved in the application scenarios and analyzing the coordination issues caused by the service provider heterogeneity.

**Reference Scenarios**

Looking at the market of service providers, it is possible to divide LASs application scenarios into two main categories: **business services** and **public services**. This characterization is based on the user typology: the services belonging to the former category have private individuals or business companies as their target, while those that belong to the latter offer services to public communities (e.g., cities, countries, etc.). In the following several LAS examples will be presented in order to provide an overview of different application fields. For a better explanation, such examples are grouped in different classes depending on the service typology. In each class it is easy to identify both business and public services even if not explicitly expressed. The following overview does not aim to be exhaustive and it could be opportunely extended over time.

**Information services**. This category includes all the services whose aim is to inform users about the location of a particular entity and the way to reach it. Location-aware information services can be viewed as an extension of the services offered by white and yellow pages, extension that is able to adapt the answers to the user context: location, movements and preferences. Services of increasing interest are guided tours, where tourists can obtain information about nearby sites of interest, such as monuments or natural spots, moving around in an unknown area. In this way, users can be informed continuously during their movements, without any operator aid. Users can indicate filters (e.g., on the distance from their position or from particular points of interest) in order to limit the output. It is important to notice that user queries can be both referred to physical objects (e.g., a particular building) and users or services location. Moreover, as observed in the previous paragraph, the output can be expressed by both physical and virtual locations. For instance, the answer to the question “Where is Mary?”, can be both “She is at home” and “She is in the yahoo chat-room”, depending on the query context.

**Emergency services**. New technologies for tracking and locating people have improved traditionally emergency services. An example is represented by emergency calls. People who usually call the emergency response agencies, such as the police, cannot often communicate their location, in many cases simply because they do not know it. Traditional 911 service, that is the emergency number in the U.S.A., is based on the fixed telephone network, thus automatically delivering the caller location to the nearest public safety agency. But if the call is made by a mobile phone the service cannot identify the caller location. Therefore, in the U.S.A., mobile operators were forced by the government to locate the callers of emergency services. In this way a new service, called E-911 (Enhanced 911), was introduced. Location technology plays an important role also in vehicle assistance services. For example, if an airplane disaster occurs, radio equipments can broadcast their location to help the rescue team operations. Such scenarios represent historical application of emergency services, but new field of application are emerging. For example, the emergency roadside assistance for drivers is a promising business area in the market of service providers. In fact, drivers often do not know their exact location where their vehicle breaks down. An infrastructure able to provide positioning information could localize the damaged vehicle and call the assistance service, improving its speed and efficiency.

**Entertainment services**. Applications such as community services allow users sharing common interests to interact each other while staying in the same real location. Forum or chat sessions can be formed “on the-fly” among people in a particular location. Today chat programs connect people across the Internet; users have to compile a list of “contacts” that they want to keep track of (the so-called “buddy list”). Next-generation programs, such as location-based chat, are able to connect people on the base of their real world location and their interests, without user-generated buddy lists. Location based games are other applications that have emerged in the last few years. Due to the increasing capabilities of mobile computing devices, many laptops or PDAs can be used as game consoles. These games merge the real world with the virtual reality. Players interact with the virtual entities of the game, moving around real buildings, roads and cities. Simple location-based games are the virtual treasure hunts, which are usually played using hand-held GPS receivers. A more complex game is Pac-Manhattan, a real-life version of the well-known Pac-Man. The playground is Manhattan, where people playing the Ghost role chase the person playing the Pac-Man role. Using cell-phone contact and Wi-Fi connections, players are tracked by a central system that controls the whole game coordinating the game characters.

**Navigation services**. This is an area of increasing business interest. The capability to find the location of a mobile user and to map this information on geographical data allows the development of several navigation-based services. A well-know example is the navigation system that is able to guide drivers to the desired target, proposing alternative routes or finding free parking. In order to offer these services the traffic and weather conditions in the interested area must be taken into account, as well as the presence of events such as accidents or roadwork. Another research field is the intervehicle communication, consisting in the exchange of messages to inform neighbor drivers about the local traffic situation or to automatically run the braking system to avoid an accident. The information obtained by this communication and the vehicle position can be sent to a central system that will be able to coordinate the traffic incoming in the area.

**Tracking services**. Services related to object tracking gave rise to increasing interest in the LAS market. Such applications deal with the coordination by a central entity of entire fleets of vehicles or teams of people. Essentially, they are based on the knowledge of real-time movements of targets. Typical examples are taxi management, air traffic coordination, personal security systems, etc.. These services can also suggest, on the basis of statistical observations, hypothesis on the future movements of a target.

Tracking services can be used by companies to locate their personnel, offering customers accurate service times. Another example refers to tracking postal packages that allow companies to know the exact location of their goods at any time. Finally, a taxi company can monitor the vehicle movements, in order to improve the efficiency in terms of fuel consumption, arrival times, etc..

**Billing services**. Another area of interest is related to toll systems. Frequently, drivers have to pay tolls to use roads, tunnels, bridges or other infrastructures. A local staff usually controls the access to such structure. People have to pay before or after passing the structure. Such an approach leads to traffic congestion, thus worsening traffic conditions. Alternatively, in some countries, such as Switzerland and Austria, drivers have to buy vignettes (i.e., colored stickers affixed to motor vehicles) proving the road toll payment, usually valid for a fixed time. But this solution does not take into account the covered distances by drivers. In order to individuate the covered distances toll systems have to keep track of the vehicles position. To solve these problems most countries have started many practical or research activities aiming at recording the driver routes, thus calculating tolls automatically. Another issue is represented by the difference of the toll systems developed by each administration entity (counties, regions, etc.). These different systems are often incompatible, thus making the management of the entire system difficult to be carried out.

## 4.3 LifeWear Innovation

Lifewear combines location and other technologies, as it can be database map reader, in order to calculate distance, burned calories and average speed. Innovation in this area is location in real time and performance suggestion in sport practices.

# 5 MOBILE SERVICES

## 5.1 Introduction & definition

Mobile networks have particular characteristics when compared to fixed networks: the mobile terminal is associated to the user, while a fixed terminal is normally associated with a family; the mobile terminal accompanies the user, allowing their location in the network; the mobile terminal is always accessible, so the user can use it at any time; and mobility is restricted depending on the terminal (typically notebook PC, PDA or mobile phone) which determines the use and availability of services.

LifeWear project needs mobile services in order to combine sensors, databases an APP able to provide information and services to the user in different technological services.

## 5.2 Current and past projects.

Evolution of mobile services has been increased more and more for the ten past years. It is very difficult explain the past because this now are the current. For this reason, we are going to define the points which continue every day.

Since 1921, when the American police began to use the wireless mobile services, this technology has improved a lot. Initially, AM communications was used to make a mobile service. FM services were appearing in 1947 to improve communications point to point. 1973 mobile services was a reality, the first radiotelephone is in the market.

1994, a new era of mobile communications became, first generation of this devices are the GSM project. This first generation is functionally limited because their only permit call or send SMS and Fax/Data transmission at 9.6 Kbps.

Second generation appears in 2000, is GPRS service and permit data sending until 384 Kbps. The devices began to incorporate Bluetooth systems. This is the new era of telecommunication services because interconnectivity between devices is present.

Third generation is the present, the mobile devices are computers and it's possible to connect sensors and other devices. The possibilities are infinite to develop assistance, alert programs and security APPs. LifeWear aims to improve the third generation of mobile communications with wearable services.

## 5.3 LifeWear Innovation

Sensors, databases and new designed APP are de added value in this task. LifeWear project aims to offer a new App series related as follows:

- App: Sleep Apnea. Mobile service to monitoring the sleep apnea in humans.
- App: Diet/Sports. Mobile service to suggest sport practices versus diet.

# 6 MULTIMODAL INTERACTIVE SYSTEMS

## 6.1 Introduction & definition

### Multimodal input

Two major groups of multimodal interfaces have merged, one concerned in alternate input methods and the other in combined input/output. The first group of interfaces combined various user input modes beyond the traditional keyboard and mouse input/output, such as speech, pen, touch, manual gestures, gaze and head and body movements. The most common such interface combines a visual modality (e.g. a display, keyboard, and mouse) with a voice modality (speech recognition for input, speech synthesis and recorded audio for output). However other modalities, such as pen-based input or haptic input/output may be used. Multimodal user interfaces are a research area in human-computer interaction (HCI).

The advantage of multiple input modalities is increased usability: the weaknesses of one modality are offset by the strengths of another. On a mobile device with a small visual interface and keypad, a word may be quite difficult to type but very easy to say (e.g. Poughkeepsie). Consider how you would access and search through digital media catalogs from these same devices or set top boxes. And in one real-world example, patient information in an operating room environment is accessed verbally by members of the surgical team to maintain an antiseptic environment, and presented in near realtime aurally and visually to maximize comprehension.

Multimodal input user interfaces have implications for accessibility. A well-designed multimodal application can be used by people with a wide variety of impairments. Visually impaired users rely on the voice modality with some keypad input. Hearing-impaired users rely on the visual modality with some speech input. Other users will be "situationally impaired" (e.g. wearing gloves in a very noisy environment, driving, or needing to enter a credit card number in a public place) and will simply use the appropriate modalities as desired. On the other hand, a multimodal application that requires users to be able to operate all modalities is very poorly designed.

The most common form of input multimodality in the market makes use of the XHTML+Voice (aka X+V) Web markup language, an open specification developed by IBM, Motorola, and Opera Software. X+V is currently under consideration by the W3C and combines several W3C Recommendations including XHTML for visual markup, VoiceXML for voice markup, and XML Events, a standard for integrating XML languages. Multimodal browsers supporting X+V include IBM WebSphere Everyplace Multimodal Environment, Opera for Embedded Linux and Windows, and ACCESS Systems NetFront for Windows Mobile. To develop multimodal applications, software developers may use a software development kit, such as IBM WebSphere Multimodal Toolkit, based on the open source Eclipse framework, which includes an X+V debugger, editor, and simulator.

### Multimodal input and output

The second group of multimodal systems presents users with multimedia displays and multimodal output, primarily in the form of visual and auditory cues. Interface designers have also started to make use of other modalities, such as touch and olfaction. Proposed benefits of multimodal output system include synergy and redundancy. The information that is presented via several modalities is merged and refers to various aspects of the same process. The use of several modalities for processing exactly the same information provides an increased bandwidth of information transfer . Currently, multimodal output is used mainly for improving the mapping between communication medium and content and to support attention management in data-rich environment where operators face considerable visual attention demands.

An important step in multimodal interface design is the creation of natural mappings between modalities and the information and tasks. The auditory channel differs from vision in several aspects. It is omnidirection, transient and is always reserved. Speech output, one form of auditory information, received considerable attention. Several guidelines have been developed for the use of speech. Michaelis and Wiggins (1982) suggested that speech output should be used for simple short messages that will not be referred to later. It was also recommended that speech should be generated in time and require an immediate response.

The sense of touch was first utilized as a medium for communication in the late 1950s.[8] It is not only a promising but also a unique communication channel. In contrast to vision and hearing, the two traditional senses employed in HCI, the sense of touch is proximal: it senses objects that are in contact with the body, and it is bidirectonal in that it supports both perception and acting on the environment.

Examples of auditory feedback include auditory icons in computer operating systems indicating users' actions (e.g. deleting a file, open a folder, error), speech output for presenting navigational guidance in vehicles, and speech output for warning pilots on modern airplane cockpits. Examples of tactile signals include vibrations of the turn-signal lever to warn drivers of a car in their blind spot, the vibration of auto seat as a warning to drivers, and the stick shaker on modern aircraft alerting pilots to an impending stall

Invisible interface spaces became available using sensor technology. Infrared, ultrasound and cameras are all now commonly used Transparency of interfacing with content is enhanced providing an immediate and direct link via meaningful mapping is in place, thus the user has direct and immediate feedback to input and content response becomes interface affordance (Gibson 1979).

| | Input | Output |
|---|---|---|
| **Acoustic** | Speech recognition | Synthetic speech (TTS, Prompts) |
| | Tune recognition | Music |
| **Tactile** | Pen<br>• Pointing<br>• Handwriting<br>• Gestures (drawings, lines, areas) | Haptics<br>• Force feedback<br>• Braille display |
| | Touch display<br>• Single-touch / Multi-touch | |
| | Mouse<br>• Pointing gestures / Drawing | |
| | Keyboard / Keypad<br>• DTMF / Arrow keys | |
| | Device orientation (gyroscope) | |
| | Thumb wheel | |
| | Pressure pads / Foot pedal | |
| | Hand gesture (glove) | |
| **Visual** | Hand gesture (computer vision) | Graphics<br>• Text / Tables<br>• Maps / Diagrams<br>• Animated highlighting<br>• Embodied characters / Visual TTS<br>• Static vs. Dynamic |
| | Gaze (eye tracking) | |
| | Body posture / presence<br>• Computer vision | |
| **Other** | GPS, Barcode scan | Smelly-vision ? |

Fig 1: Interactive modalities overview

| **Consumer** | **Business/Professional** | **Arts/Entertainment** |
|---|---|---|
| • Need to be usable by wide range of inexperienced users<br>• Adaptation: novice vs. expert | • Users may be more willing to learn controlled, limited interaction languages e.g. military symbology | • Recognition/understanding capabilities may be less important Can in fact be part of the experience |
| **Map-based information access and navigation** | | **Gaming** |
| • City / travel guide: e.g. MATCH, SmartKom mobile, DeepMap, AUGUST<br>• Apartment finder: Adapt<br>• Receptionist: MVPQ, Dr. Who, MACK, NUMACK<br>• Tickets: MASK, SmartKom public | • Mobile field technicians: "can I dig here"<br>• Military command and control e.g QuickSet, Cubricon, Eucalyptus<br>• Disaster response<br>• Law enforcement | • Most games are complex visual displays<br>• Weapon/tool selection by speech<br>• Communicative interaction e.g. NICE system |
| **Computer-aided design** | | **The Arts** |
| • Bathroom design (COMIC) | • Circuit diagrams<br>• Network visualization | • Interactive cinema Toni Dove: Artificial Changelings<br>• Installation art<br>• Museum guides |
| **Other complex visual displays** | | |
| • Calendar (Vo and Waibel, Mipad)<br>• Tax forms (Xtra)<br>• Corporate directory (PDAMVPQ) | • Medical applications: Echart (input) / MAGIC (output)<br>• Aircraft maintenance: Voicelog | |
| **Educational applications and Digital manuals** | | |
| • Autotutor, STEVE, Cosmo, WIP, PPP | | |

Fig2: Interactive Multimodal Example applications

## 6.2 Current and past projects

**Passepartout**

Passepartout focused on the convergence of digital systems architectures and applications for integrated media ambiance in the home. This was achieved by coupling new devices from the consumer electronics (CE) industry to home networks for rendering scalable content for HDTV and interactivity in a seamless fashion. Integral to the concept was reactive access and interactivity via high-resolution graphics using object-oriented media. The project goal was to make a step forward towards ambient intelligence through mass personalisation of reactive content – practical elements of MPEG-4 and MHP-GEM as Blu-Ray Java (BD-J), supported by World Wide Web Consortium (W3C) standards such as synchronised multimedia integration language (SMIL) and synthesis/syndication in XML. Project demonstrations stretched far beyond infrastructure and basic services for home networks, affecting also content and human-system interaction via unique devices.

**Digital Headend**

DIGITAL HEADEND has provided European industry with a new digital headend solution, demonstrating the excellence of Europe's digital video broadcasting standards (DVB based on MPEG). A new concept developed within the project provides a bridge between the data communications world and the video broadcasting world, supporting new interactive broadband services to the home.

## 6.3 Lifewear innovation

LifeWear works focused on Ubiquitous computing scenario will use body posture detection sensors to detect if the user is realizing his sport practice correctly, compare it with other data aquired by LifeWear middleware and merging this information provide useful information to the user. Also all mobile apps will use touch displays.

# 7 WEARABLE DEVICES AND COMPUTING

## 7.1 Introduction & definition

One of the visions of wearable computing is that the user performs his primary task (walking, talking, working, etc.) while simultaneously using the wearable. Thus an important requirement for a wearable input device is that it is unobtrusive. Traditional methods of computer interaction, such as textual (using a keyboard) and graphical (using a mouse) requite both the user's physical and cognitive attention. For wearables we need to go beyond these traditional modalities and explore variations of these as well as to develop completely new modalities that capitalize on the body worn aspect of wearable computing.

## 7.3 Current and Past Projects

### Text input

When thinking about laptops or desktop PCs than almost exclusively QWERTY keyboards are used. On mobile devices methods like T9, multi-tap and stylus based approaches (e.g. graffiti) are used. All of these methods are based on the assumption that not just a keyboard, keypad or stylus is used but also a display that shows the user the typed text.

Therefore all of these texts input methods cannot be used simultaneously with another task (e.g. walking or talking) without heavily disturbing the latter. One potential solution for this is the Twiddler, a one-handed keyboard which is depicted in next figure [Lyons 2004, Starner 2007a].


**Fig. 3. Twiddler [Starner 2007a]**

Twiddler is a mobile keyboard with a 3x4 button layout, which can be used with one hand. The user can input text by pressing one or two buttons. This input device was compared with multi-tap – and qwerty – based solutions and the results indicate that Twiddler can be the ideal solution when used by people who are not used to qwerty based keyboards and/or in situation when both hands cannot be used and/or typing in text is not the primary task [Clawson 2005].

### Voice input

One of the most natural ways of interaction and communication in our everyday life is the usage of language. Although there have been many attempts to use this modality this possibility is very rarely used. So there are for instance many systems for dictating text when using a PC, but most of them are just rarely used in specific application. Furthermore most mobile phones provide functionalities for text input (e.g. saying the name of a person in the address book triggers a corresponding call) but these are again very rarely used. One important reason is that speech interfaces are not appropriate in many situation e.g. when sharing the office with many others, in meeting or while using the public transport.

The latter problem was addressed by the Dual-Propose Speech project in which a person uses a wearable interface consisting of a head-up display and a headset / microphone [Lyons 2005, Starner 2007a]. The user of this system can check her calendar using the head-up display while talking with another person. Therefore the user voice is interpreted and the corresponding entries in the calendar are shown and new entries are created. The advantage of this approach is that the normal conversation between two persons is almost not disturbed by the usage of such a system.


**Fig. 4. Dual-Propose Speech system based on a head-up display that display a calendar**

Headsets for voice input and audio output has become very popular in the last years through the success of internet telephony systems like Skype, through policies that forbid to hold a mobile phone in your hands while driving and the need for hands free communication e.g. in call centers. Especially the widespread Bluetooth headsets show how business people, taxi drivers and mobile phone users now use an originally very futuristic in- and output device. One important factor at this is the price of such devices. One of the first Bluetooth headsets was for instance the GN 9000 from GN Nordkom (now Jabra), which was sold in 2000 for circa 650 Euros [Heise 2000]. Currently such Bluetooth headsets can be bought for 20-50 Euros which is one important factor for their success. These headsets are a very interesting example for a technology of which many people in 2000 thought that almost nobody would wear it why walking around or shopping. But in the meanwhile it is quite common to do this and it is often seen in everyday life.

**Fig. 5. Left – GN 9000 from 2000, Right – BT135 from 2007**

### Context recognition and input from body-worn sensors

A number of different sensing modalities have been used as inputs for wearables.

The focus of most of these sensor arrangements is to gather information about the user's context – where she is, what she is doing, when she is doing it, what are her preferences from last time, etc. Context is the most essential user-input modality for future wearable systems [Abowd 1998]. The more the wearable computer knows about it's user, the more it can be of use – and the less obtrusive it is – to whatever task the user is doing. In this section, we briefly highlight a selection of sensors used in two main areas of context recognition: location and activity recognition.

The first prominent research area for context is localization or localization sensors. One could distinguish at this between satellite positioning (e.g. GPS), cellular positioning (e.g. via GSM) and indoor positioning (WLAN fingerprinting, RFID, Infrared, Ultrasound). Typical worn or carried sensors at this are GPS devices (e.g. in navigation systems or mobile phones), mobile phones, badges (infrared, ultrasound) or Laptops.

The second prominent research area is user activity recognition. User activities can include ambulatory locomotion (running, sitting, standing, etc.), fine-grained manipulative gestures (pick up a saw, use a hammer), communication (talking, shaking hands, using sign language) and even general situation (working, eating, reading). This diversity demands an equally diverse assortment of sensors and methods that can be used for recognition. For physical activities, the most common sensor used of late has been the accelerometer. Sound (using microphones) is also fairly popular.

Other simple sensors, such a switches and tilt sensors can be used in situations where there are power constraints, and the recognition task is simple enough.

### Data collection and sensor systems.

As the use of body-worn sensors has grown, a number of commercial sensor solutions have become available. The MT9 system, from Xsens, incorporates a 3-axis accelerometer, magnetic field sensor, and a gyroscope. The Xbus system allows several Xsens boxes to be connected together, transmitting the data over a serial line or via Bluetooth. A particularly useful feature of this system is the on-board processing of feature data and the option of generating absolute positioning.

For physiological sensor readings, there are several commercial solutions available, such as the Nexus-10 from MindMedia.

For many researchers however, the specific requirements of a particular sensor combination means that more often than not a custom data-collection solution is often used – a laptop or PDA in a backpack connected by wire to the sensors.

An earlier work at ETH Zurich was the WearNet platform [lukowicz2002wearnet]. This was a network of wired bodyworn nodes based on 3-axis accelerometers. In 2005 a sensor node was developed (also at ETH) which included capabilities not only for multiple sensor types (e.g. accelerometers, microphone, light sensors) but could be operated wirelessly [BMLT05]. This so-called SensorButton (it is a round device with holes in the middle for convenient sewing to garments) incorporates an MSP for rudimentary feature calculation and classification.

QBIC, a Wearable Computer integrated in a Belt, was developed at ETH Zurich to provide a wearable medium-powered platform for general wearable applications (http://www.wearable.ethz.ch/qbic.0.html). It is built on an Xscale processor, incorporates a

USB hub, VGA output and MMC-based storage. Some of the applications being developed for the QBIC include:

- To monitor medical parameters of critical patients 24 hours a day
- To collect and analyse data on user movement for rehabilitation
- To collect and analyse data on user movement for dance projects.
- As a computer for reality games
- As a guide to tourists or travelers

The eWatch [MRSS06], a joint project between Carnegie Melon and TU Munchen, incorporates an accelerometer, temperature, light sensor and a microphone. This uses Bluetooth and IR to communicate with the outside world. One advantage of this system is that it is built into wristwatch-style housing and incorporates a small display.

### Tactile Output: Vibration

In the ActiveBelt project a belt was augmented with several vibrators and LEDs, with a GPS receiver and a geomagnetic sensor [Tsukada and Yasumrua 2004]. This device was used to guide to user through the desired destinations through corresponding tactile feedback provided by the 8 vibrators attached to the belt. The vibrators were attached in such a way that the user knew whether she has to go straight on, to the left, to the right or to turn around.The Rotating Compass is a further system which guides the user through tactile feedback [Rukzio et al. 2005]. In this system a rotating compass – a compass whose needle rotates all the time – is displayed at all crossings and a mobile device is used. When the user approaches a rotating compass then the mobile phone vibrates in the moment in which the correct direction of the user is indicated. Another project which used tactile feedback is the Haptic Shoes project which communicates stock market information through corresponding vibration patterns to the user [Fu and Li 2005].

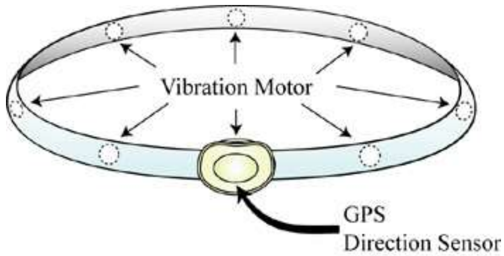


**Fig. 6. Device for tactile feedback**

### On-Body Displays

Displays attached to the human body (especially the arm or wrist) are another popular wearable output device. The advantage when compared with mobile phones is that these devices are always visible whereby a mobile phone is usually located in a hand bag or in a trouser pocket.

The Zypad WL 1000 from the EUROTECH group is a wrist worn PC that runs Windows CE 5.0 / Linux and supports WLAN, Bluetooth and GPS [http://www.zypad.com/]. The weight of the device is 290 grams, supports hands free operation and provides also a stylus for more fine-grain user input. On the top of the device are several buttons located that support the quick control of the device. Through the GPS receiver it is possible to track the user at any time and to recognize also when the user has been motionless for some time. Pioneer presented in 2003 a prototype called Pioneer Computer Jacket that provided an organic film electro-luminescent display [@I4U]. Eleksen offers a Vista Display Controller integrated in a laptop case that provides an interface to the corresponding laptop but can be in principle also used for MP3 playback or a photo album [eleksen.com].

**Fig. 7. Pioneer Computer Jacket and Eleksen Vista Display Controllers**

These two examples show that, especially companies are interested in such on-body displays and that the corresponding technology is available. One can image that in a few years such displays are integrated in many jackets or cases and that they provide an interesting alternative to the screen of a mobile device.

### Head Mounted Displays (HMD) and Heads-up displays

The most prominent output devices in wearable computing is a head mounted display or a heads-up display. An HMD is a display device worn on the head, using a helmet or goggles, which provide the illusion of a floating monitor in the front of the users face [TechWeb HMD 2007]. HMDs can be classified into single-eye units which allow the interaction with the physical world and dual-eye systems which are typically used for virtual- or augmented reality applications.

Martin Heilig is seen as the inventor of HMDs because he filed a corresponding patent in 1962 that describes a HMD that supports stereophonic television and developed a corresponding system (which was rather a floor mounted display) which was called “Sensorama” [Rheingold 1991]. Ivan Sutherland developed in the late 1960s the first head-mounted display that was used for very basic virtual and augmented reality applications. The HMD was so heavy was therefore suspended from the ceiling. This system was called the Ultimate Display, provided a stereoscopic image thought the usage of two CRT displays and had a mechanical tracking system [Sutherland 1965]. Bell Helicopter worked in the 1960s on HMD displays as well. The HMD showed information recorded by infrared cameras to help the pilot to land in bad weather conditions or conventional cameras provided information from the bottom of the helicopter [Rhodes 2007]. In the following years HMDs became smaller which means also fewer weights, cheaper and had a much better performance regarding their resolution and image quality.

Important characteristics or quality attributes for HMDs are field-of-view, resolution, stereo capability, color depth, refresh rate and collimation distance. A comprehensive survey of HMDs can be found in [Latham 2001] unfortunately there is no more up to date overview with a similar quality available.

Inition.com provides a comprehensive overview of currently available binocular and monocular HMDs. Monocular HMDs provide typically a resolution of 640x480 or 800x600, have a weight of circa 100g, a field of view of 28-35 degree (diag) and cost between 740 and 2375 Euro (accessed on 31/08/2007). Binocular HMDs provide typically a resolution from 640x480 to 1280x1024, have a weight from 100g to 2.5 kg, a field of view of 26-177 degree (diagonal), distance to the eye of 52 – 74 mm and cost between 650 and over 100.000 Euro (accessed on 31/08/2007).

A recent survey showed that most available HMDs are still not good enough regarding their horizontal and vertical view and price [Boger 2007]. Furthermore they confirmed that field of view, response, contrast, resolution and weight are the most important factors of a HMD.

As the focus of this deliverable are wearable devices for interaction with media in the following HMDs or Head-up displays will be presented which are relatively cheap and lightweight. Such devices might be the basis for future devices

used by mobile workers or conventional media users. Although the presented devices might be used for such scenarios they are still far away from being widespread and do not provide all the criteria needed for mass marked adoption. But it can be assumed that these devices will improve over years and might eventually be as successful as Bluetooth headsets.

Icuiti (Icuiti.com) offers several products like the AV230, DV920, AV920, VR920, M920 and the iWear for iPod in its video eyewear series. The binocular non-immersive HDMs have the form factor of eyeglasses and their primary usage is to watch videos e.g. while travelling. These devices can be connected with portable media or DVD players, camcorders or mobile phones. The AV230 provides two 320x240 LCD displays, 24 bit true color, 60Hz update rate, a battery lifetime of 5 hours, a weight of circa 100 gram, an update rate of 60Hz and costs circa 250 USD. Icuiti states that the impression of the user would when using an AV230 is comparable with watching a movie on a 44” display. The DV920 from Icuiti is more expensive that the AV230 as it costs circa 250 USD. Each of the two LCD displays has 920.000 pixel and 26 degree of field. The M920 is a very light-weight HMDs in form of a headset that can be connected to Compact Flash Type II or PCMIA slots of Pocket PC based PDAs.

**Fig. 8. Head Mounted Displays (HMD) and Heads-up displays**

Oriscape offers various products in their I-Vision Video Glasses, Cyberman Head Mounted Display and Cyberman 3D Head Mounted Display series. The GVD 420 is part of the I-Vision

Video Glasses series, can be connected to various devices such as DVD players or an Ipod Video, has 800x225 Pixel, 22 degree view of angle and the impression of the user can be compared, according to Oriscape, with a 30" screen. The GVD 310A belongs to the Cyberman Head Mounted Display series, costs circa 235 USD and is comparable with the GVD 420. The Cyberman GVD510-3D belongs to the Cyberman 3D Head Mounted Display series, provides two 640x480 displays, 28 degree view of angle, costs circa 825USD and the impression of the user can be compared, according to Oriscape, with a 40" screen 6 feet away.

**Fig. 9. Head Mounted Displays (HMD) and Heads-up displays**

Shimadzu offers the DataGlass2/a, which is a light weight monocular HMD with a see-through prism optic. These devices can be connected to a computer monitor port and cost circa 2750 USD [Tekgear.ca]. I-Port from Creative Display Systems is a binocular HMD based attached to spectacles, has a weight of 50 gram, a resolution of 800x600 and costs circa 7000 USD [creativedis.com]. The Myvu personal media viewer can be used for watching video, is sold via department stores, costs circa 200-300 USD and is probably one of the first real consumer HMD [myvu.com].

**Fig. 10. Head Mounted Displays (HMD) and Heads-up displays**

### Audio

Audio feedback is probably one of the most common output modalities. Mobile phones provide a speaker that often supports also hands-free and conference scenarios, earphones used for listening to music or radio are often provided for free when buying a new mobile phone and Bluetooth headsets provide earphones too.

## 7.4 Lifewear innovation

Lifewear aims to develop wearable devices in three main fields: sports, firefighting and e-health. Developing these wearable devices are one of the main goals of the project. In each area mentioned above devices feed the core application with real-time data.

# 8 BODY AREA NETWORKS

## 8.1 Introduction & definition

Body area network (BAN), wireless body area network (WBAN) or body sensor network (BSN) are terms used to describe the application of wearable computing devices. This will enable wireless communication between several miniaturized body sensor units (BSU) and a single body central unit (BCU) worn at the human body.

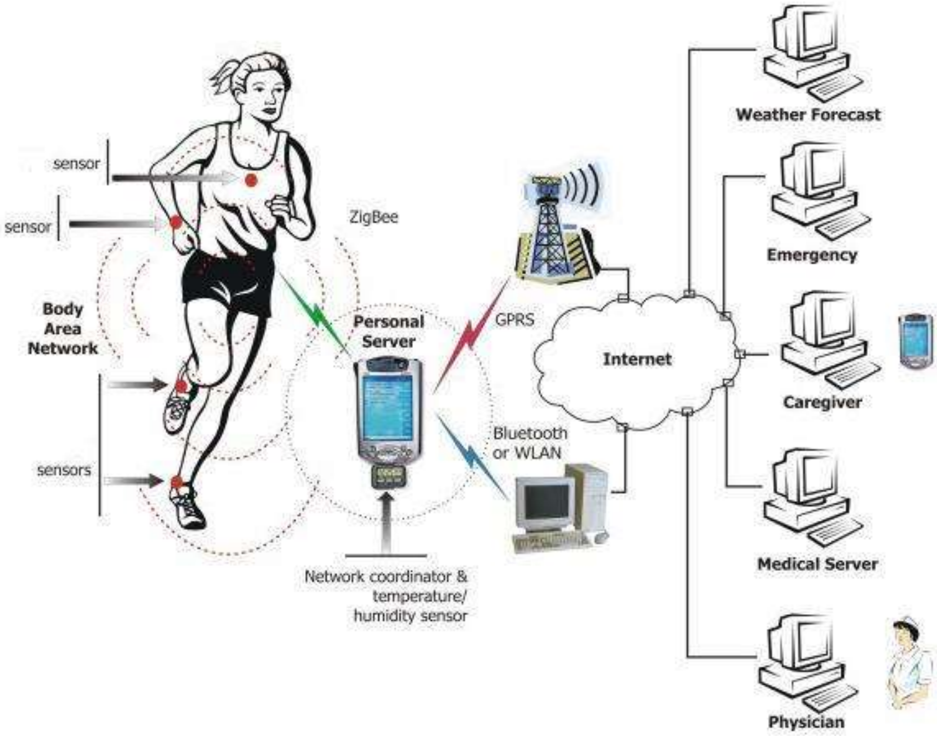


**Fig. 11. BAN graphic explanation**

The rapid growth in physiological sensors, low power integrated circuits and wireless communication has enabled a new generation of wireless sensor networks. These wireless sensor networks are used to monitor traffic, crops, infrastructure and health. The body area network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records via Internet for example.

## 8.2 Current and past projects

Initial applications of BANs are expected to appear primarily in the healthcare domain, especially for continuous monitoring and logging vital parameters of patients suffering from chronic diseases such as diabetes, asthma and heart attacks.

The first projects around this methodology were focused in radiofrequency connection between man and machine. The first projects in human bodies with sensor were prepared to detect Pulse Rate, Temperature, Humidity etc. Today, the projects in body sensor areas aim to develop technologies as follows:

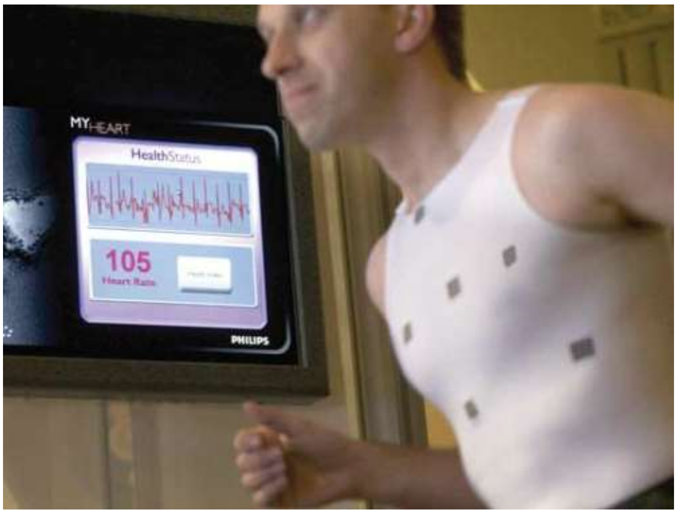


**Fig. 12. Monitoring with wearables**

### Wearable sensors

The sensors on the body to monitor responses and physical States are present from 3 decades ago, but the current sensors deliver information in real time and are implemented in the clothes. I. e. , the athlete does not have to try to give as much of themselves with cables dangling him everywhere. Waterproof synthetic fibres with antibacterial action have been given this opportunity to scientists and athletes (also military) in order to be in control of the entire body through micro wireless sensors.

### Edible computers

Developed by NASA, these edible sensors are the same that are used in the astronauts and contain a quartz crystal and a micro-batería wrapped in silicone. It provides information on vital signs such as heart rate and temperature.

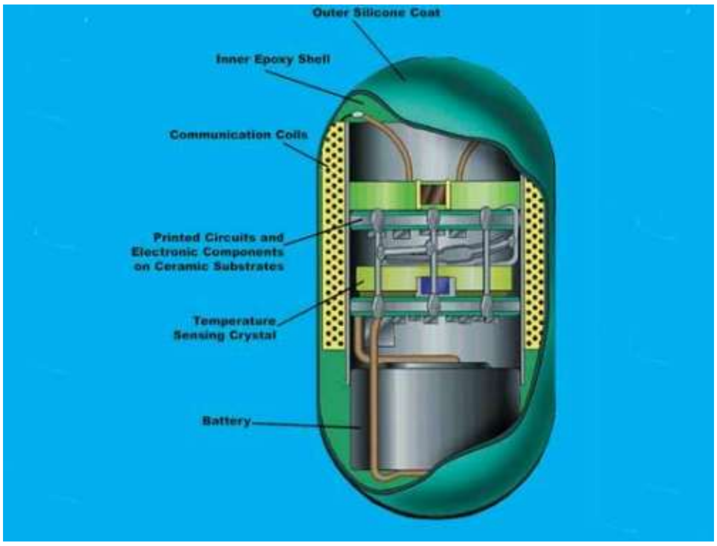


**Fig. 13. Electronic capsule detail**

**Body extreme Image and Sound**

Other applications of this technology include sports, military, or security. Extending the technology to new areas could also assist communication by seamless exchanges of information between individuals, or between individual and machines.

**Fig. 14. Video a sound camera with Xigbee.**

Other applications of this technology include sports, military, or security. Extending the technology to new areas could also assist communication by seamless exchanges of information between individuals, or between individual and machines.

The image and the video in sports have a critical relevance, which are constantly improving to bring better ways to visualize sports, take data of them almost in real time and also withstand heights, temperature, climatic States and blows. Bluetooth, RFID, XigBee, and recently ANT +, has developed the possibility of capture incredible frames in real time and process this information to obtain multiple services.

**Real Time technical assistance.**

A system of computer and video cameras 600 fps that capture the trajectory of the ball as a reference to know if he was or not to a goal, if crossed a line, etc. Other systems are the line of arch, with a similar operation. Chips in balls and different instruments used in each sport and analysis software in real-time that would make that sports were less unjust situations and thus avoiding part of the violence that is generated. This is being developed and is becoming more effective. Associated a body sensor, the body area network is to be able a revolution . [4]

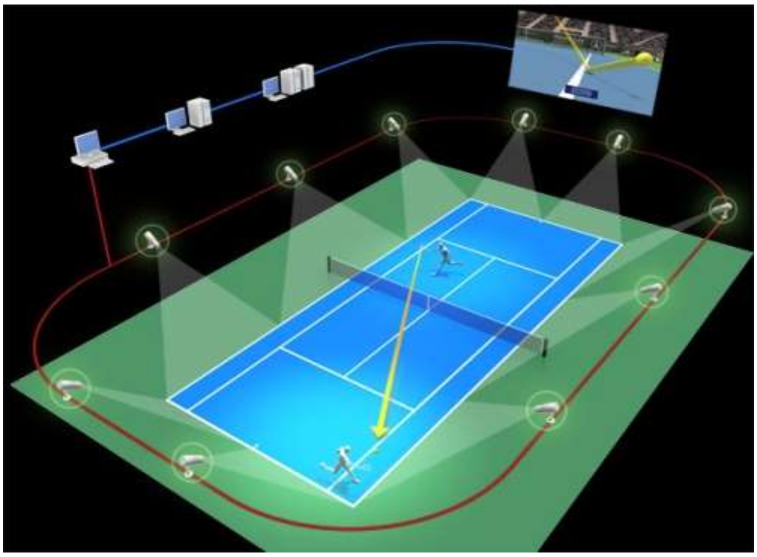

**Fig. 15. Body area network and control cameras.**

## 8.3 LifeWear Innovation

Lifewear presents new researches way. For example in thermal stress recognition for fighfigters LifeWear aims to new working line in security field, moreover wearable sensor are played in Sports App.

# 9 CHRONIC DISEASE MANAGEMENTS

## 9.1 Introduction & definition

The cost of managing chronic diseases is the largest portion of health care expenditures in developed countries. For example, the prevalence of adult acquired diabetes has been rising, in concert with increasing rates obesity. The CDC has termed it an "epidemic", especially in light of the massive costs incurred by the health care system due to diabetes.

The deleterious health effects of many chronic conditions can be diminished by behavior modifications. While few would underestimate the difficulty of having patients lose weight or exercise more, good management of blood sugar in diabetes is both objectively measurable and strongly correlated with reduced end-organ damage.

This is among the reasons why Research2Guidance has recently nominated diabetes as the condition most likely to be most targeted by mobile medical software and devices (mHealth). This finding is part of their recently published Global Mobile Health Market Report 2010-2015. This is the same report that also predicted that, in the future, medical apps are likely to be distributed by physicians and health care institutions.
This time Research2Guidance is highlighting the portion of the survey where they looked into where mobile devices have the most potential to affect health outcomes. While other chronic conditions such as hypertension and obesity have larger populations, the market researchers felt diabetes had the largest market potential due to the huge cost saving potential, the demographic & geographic overlap between smartphone users and diabetics and the real potential to improve sugar management using mobile devices. As per Research2Guidance,
To manage patients diabetes in "real time" and "on-the-go" situations, shared information within the healthcare industry and especially between medical professionals whilst "on-the-go" is essential.

Medgadget recently reported that Sanofi-Aventis and AgaMatrix have deployed in Europe the iBG Star, an integrated iPhone app and glucometerfor measuring and recording blood sugars. This app stores recorded sugars and allows for data to be easily "communicated to healthcare professionals." Unfortunately, this likely means that the app sends an email. And thus, it demonstrates one of bottlenecks for behavior modification by mHealth, i.e. the lack of integration into health care professionals' workflow. In this vein, the efforts of EHR vendors such as Practice Fusion to develop APIs for direct, real time importation of patient data could be a key ingredient.
Nevertheless, the excitement around mobile medical software and devices is evident in this quote in the blog Diabetes Mine from noted endocrinologist Bruce Bode, MD:

Even then, the major driving force for adoption will remain the potential cost savings. Again, as per Research2Guidance, the direct costs alone of diabetes for a patient with diabetes in Western European countries are between 4,000 and 5,000 EUR annually.

## 9.2 Current and past projects

The ITEA 2 AIMES project (Advanced Infrastructure for Medical Equipment Management and Services) has developed a fully integrated service infrastructure for medical equipment management and services to help cut the ever growing cost of high technology healthcare. It covers the integration of management tools into an appropriate communications infrastructure with distributed condition monitoring, diagnosis and remote access to medical equipment. It also enables management and tracking of mobile medical devices using radio-frequency identification (RFID).

## 9.3 LifeWear Innovation

Lifewear will also work on the chronic disease management in the healthcare scenario. Using an app from Mobilera in this scenario will provide the user and his doctor to receive real time information about his health status.

# 10 REFERENCES

Asada, H. H., Shaltis, P., Reisner, A., Rhee, S., Hutchinson, R.C. (2003). Mobile Monitoring with Wearable Photoplethysmographic Sensors. In: IEEE Engineering in Medicine and Biology Magazine, 22(3), pp. 28-40.

Bien, Z. Z., Park, K.-H., Kim, D.-J., Jung, J.-W. (2004). Welfare-Oriented Service Robotic Systems: Intelligent Sweet Home & KARES II. In: Z. Z. Bien, D. H. Stefanov (Eds.): Advances in Rehabilitation Robotics: HumanFriendly Technologies on Movement Assistance and Restoration for People with Disabilities, Lecture Notes in Control and Information Sciences, Springer, Berlin, Germany, pp. 57-94.

Bohn, J., Coroama, V., Langheinrich, M., Mattern, F., Rohs, M. (2004). Living in a World of Smart Everyday Objects – Social, Economic, and Ethical Implications. In: Journal of Human and Ecological Risk Assessment, 10(5), pp. 763-786.

Braun, G., Nelles, S., Rumm, P. (2009). Telemonitoring von Gesundheits- und Vitaldaten – Ökonomischer und qualitativer Nutzen bei chronischen Erkrankungen. In: Proceedings of AAL'09. VDE, Berlin, Germany. CD-ROM.

British Department of Health (2001). National Service Framework for Older People. Department of Health, London, UK, Crown Copyright. Brown and Adams.

Cook, D. J., Das, S. K. (2007). How Smart are Our Environments? An Updated Look at the State of the Art. In: Journal of Pervasive and Mobile Computing, 3(2), pp. 53-73.

Demiris, G., Tan, J. (2005). Rejuvenating Home Health Care and Tele-Home Care. In: J. Tan (Ed.): E-Health Care Information Systems: An Introduction for Students and Professionals. Jossey-Bass, San Francisco, pp. 267-290.

Ferguson, G. T. (2003). Have Your Objects Call My Objects. In: Harvard Business Review, 80(6), pp. 138-143.

Friedman, R. Kazis, L., Jette, A. (1996). A Telecommunication System for Monitoring and Counseling Patients

with Hypertension: Impact on Medication Adherence and Blood Pressure Control. In: American Journal of Hypertension, 9, pp. 285-292.

Gellersen, H.-W., Beigl, M., Krull, H. (1999). The MediaCup: Awareness Technology Embedded in an Everyday Object. In: Proc. of Intern. Symp. on Handheld and Ubiquitous Computing, Springer, Heidelberg, pp. 308-310.

Gellersen, H.-W., Schmidt, A., Beigl, H.-W. (2000). Adding Some Smartness to Devices and Everyday Things. IEEE Workshop on Mobile Computing Systems and Applications, December 7 - 8, Monterrey, USA.

Georgia Institute of Technology (2004). From Research to Market: Smart Shirt Moves. Georgia Institute of Technology, GA, USA.

Gopalsamy, C., Park, S., Rajamanickam, R., Jayaraman, S. (1999). The Wearable Motherboard: The First Generation of Adaptive and Responsive Textile Structures (ARTS) for Medical Applications. In: Virtual Reality, 4, pp. 152-168.

Halin, N., Junnila, M., Loula, P., Aarnio, P. (2005). The LifeShirt System for Wireless Patient Monitoring in the Operating Room. In: Journal of Telemedicine and Telecare, 11, pp. 41-43.

Jagos, H., Oberzaucher, J., Zagler, W. L. (2007). Erste Schritte bei der Entwicklung instrumentierter Schuhe zur Sturzvorbeugung alter Menschen. IKTForum.

Jerant, A. F., Azari, R., Nesbitt, T. S. (2001). Reducing the Cost of Frequent Hospital Admissions for Congestive Heart Failure: A randomized Trial of a Home Telecare Intervention. In: Medical Care, 39(1), pp. 1234-1245.

Jung, J. W., Lee, C. Y., Lee, J. J., Bien, Z. Z. (2003). User Intention Recognition for Intelligent Bed Robot System. In: Proceedings of the Eighth International Conference on Rehabilitation Robotics (ICORR'03), pp 100-103.

Kikin-Gil, R. (2005). Buddybeads: Techno-Jewelry for Non-Verbal Communication within Teenager Girls Groups. In: Personal and Ubiquitous Computing, 10(2-3), pp. 106-109.

Krebs, H. I., Hogan, N., Volpe, B. T., Aisen, M. L., Edelstein, L., Diels, C. (1999). Robot-Aided NeuroRehabilitation in Stroke: Three-Year Follow-Up. In: Proceedings of the Sixth International Conference on Rehabilitation Robotics (ICORR'99), pp. 34-41.

Becker, C., Dürr, F. (2005). *On location models for ubiquitous computing*. ACM Personal Ubiquitous Computing. **9**(1), 20-31. [An overview of existing location models, based on general properties of both symbolic and geometric coordinates, allowing for position, range, and nearest neighbor queries]

[Aarts and Appelo(1999)] Aarts E, Appelo L (1999) Ambient intelligence: thuisomgevingen van de toekomst. IT Monitor (9):7–11

[Aarts and de Ruyter(2009)] Aarts E, de Ruyter B (2009) New research perspectives on ambient intelligence. Journal on Ambient Intelligence and Smart Environments (JAISE) 1(1):5–14

[Aarts et al(2002)] Aarts E, Harwig R, Schuurmans M (2002) Ambient intelligence. In: The invisible future: the seamless integration of technology into everyday life, McGraw-Hill, pp235–250 Ambient Intelligence and Smart Environments: A State of the Art 29

[Aghajan et al(2009)] Aghajan Y, Lacroix j, Cui J, van Halteren A, Aghajan H (2009) Home Exercise in a Social Context: Real-Time Experience Sharing using Avatars, Intetain'09

[Aghajan and Cavallaro(2009)] Aghajan H, Cavallaro A (2009) Multi-Camera Networks: Principles and Applications, Academic Press 2009

[Aghajan et al(2009)] Aghajan H, Augusto J, Delgado R (2009) Human-centric Interfaces for Ambient Intelligence, Academic Press 2009

[Augusto(2007)] Augusto JC (2007) Ambient Intelligence: the Confluence of Ubiquitous/Pervasive Computing and Artificial Intelligence, Springer London, pp 213–234. Intelligent Computing Everywhere

[Augusto and Nugent(2006a)] Augusto JC, Nugent CD (eds) (2006a) Designing Smart Homes. The Role of Artificial Intelligence. Springer-Verlag

[Augusto and Nugent(2006b)] Augusto JC, Nugent CD (2006b) Smart homes can be smarter.

[Augusto and Nugent(2006a)], Springer-Verlag, pp 1–15

[B¨ohlen(2009)] B¨ohlen M (2009) Second order ambient intelligence. Journal on Ambient Intelligence and Smart Environments (JAISE) 1(1):63–67

[Brooks(1990] Brooks R (1990) Elephants Don't Play Chess. In: Robotics and Autonomous Systems 6, pp. 3–15

[Cook and Das(2004)] Cook D, Das S (2004) Smart Environments: Technology, Protocols and Applications (Wiley Series on Parallel and Distributed Computing). Wiley-Interscience

[Dertouzos(2001)] Dertouzos M (2001) Human-centered systems. In: The Invisible Future, McGraw-Hill, pp 181–192

[Gibson J(1979)] Gibson J (1979) The Ecological Approach to Visual Perception. Houghton Mifflin, Boston

[Huuskonen(2007)] Huuskonen P (2007) Run to the hills! ubiquitous computing meltdown. In: Augusto JC, Shapiro D (eds) Advances in Ambient Intelligence, no. 164 in Frontiers in Artificial Intelligence and Applications (FAIA), IOS Press

[IST Advisory Group(2001)] IST Advisory Group (2001) The european union report, scenarios for ambient intelligence in 2010. URL: ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf

[Maturana and Varela(1980)] Maturana H and Varela F (1980) Autopoiesis and Cognition: The Realization of the Living. D. Reidel Publishing Co., Dordrecht, Holland

[Nakashima(2007)] Nakashima H (2007) Cyber assist project for ambient intelligence. In: Augusto JC, Shapiro D (eds) Advances in Ambient Intelligence, IOS Press Inc.

[Newell and Simon(1963)] Newell A, Simon H (1963), GPS: A Program that Simulates Human Thought. In: Feigenbaum E, Feldman J (eds) Computers and Thought, McGraw-Hill

[Ramos et al(2009)] Ramos C, Dey A, Kameas A (2009) Thematic Issue on Contribution of Artificial Intelligence to AmI. Journal on Ambient Intelligence and Smart Environments (JAISE)

[Spohrer et al(2007)] Spohrer J, Maglio P, Bailey J, Gruhl D (2007) Steps Toward a Science of Service Systems, IEEE Computer 40(1):71–77

[Streitz et al(2007)] Streitz NA, Kameas A, Mavrommati I (eds) (2007) The Disappearing Computer, Lecture Notes in Computer Science, vol 4500, Springer

[Weiser(1991)] Weiser M (1991) The computer for the twenty-first century. Scientific American 165:94–104

[Weiser(1993)] Weiser M (1993) Hot topics: Ubiquitous computing. IEEE Computer 26(10):71–72

[Zelkha(1998)] Zelkha E (1998) The future of information appliances and consumer devices, palo Alto Ventures, Palo Alto, California

[Lyons 2004] Kent Lyons, Thad Starner, Daniel Plaisted, James Fusia, Amanda Lyons, Aaron Drew and E. W. Looney. Twiddler Typing: One-Handed Chording Text Entry for Mobile Phones. CHI. Vienna, Austria. April 2004.

[Lyons 2005] Kent Lyons, Christopher Skeels, Thad Starner. Providing support for Mobile Calendering Conversations: an Evaluation of Dual-Purpose Speech. Mobile HCI 2005.

[Clawson 2005] James Clawson, Kent Lyons, Thad Starner, and Edward Clarkson. The Impacts of Limited Visual Feedback on Mobile Text Entry for the Twiddler and Mini–QWERTY Keyboards. ISWC 2005.

[Starner 2007a] Interfaces for augmenting face-to-face conversation

[Heise 2000] Erste Bluetooth-Sprechgarnitur, http://www.heise.de/newsticker/meldung/12191

[Abowd 1998] Gregory D. Abowd, Anind K. Dey, Gregory Abowd, Robert Orr & Jason Brotherton. Context-awareness in wearable and ubiquitous computing. GVU Technical Report GIT-GVU-97-11, 1997.

[Lukowicz at al. 2004] P.Lukowicz, J.A.Ward, Junker, H., Tr¨oster, G., A.Atrash, T.Starner, 2004. Recognizing workshop activity using body worn microphones and accelerometers. In: Pervasive, LNCS.

[Tsukada and Yasumrua 2004] Tsukada, K. and Yasumrua, M.: ActiveBelt: Belt-type Wearable Tactile Display for Directional Navigation, Proceedings of UbiComp2004, Springer LNCS3205, pp.384-399 (2004).

[Rukzio et al. 2005] Enrico Rukzio, Albrecht Schmidt, Antonio Krueger. The Rotating Compass: A Novel Interaction Technique for Mobile Navigation. CHI '05: Extended abstracts of the 2005 conference on Human factors and computing systems, Portland, Oregon, USA, 2005.

[Fu and Li 2005] Xiaoyan Fu and Dahai Li. Haptic shoes: representing information by vibration. APVis '05: proceedings of the 2005 Asia-Pacific symposium on Information visualisation. 2005.

[@I4U] http://www.i4u.com/article407.html

[TechWeb HMD 2007] http://www.techweb.com/encyclopedia/defineterm.jhtml?term=head+mounted+display

[Reingold 1991] Howard Rheingold. Virtual Reality. Summit Books. 1991.

[Sutherland 1965] I.E. Sutherland. The Ultimate Display. Proceedings of IFIPS Congress 1965, New York, May 1965, Vol. 2, pp. 506-508

[Rhodes 2007] Bradley Rhodes. A brief history of wearable computing. http://www.media.mit.edu/wearables/lizzy

[Latham 2001] Roy Latham, Ben Delaney and P. Y. Cheng. Our Annual Survey of Head-Mounted Displays. Real Time Graphics Vol. 10 No. 2. 2001.

[Boger 2007] Yuval Boger Are Existing Head-Mounted Displays 'Good Enough'? A summary of a worldwide HMD survey on past experience and future expectations from HMDs, Sensics, Inc. 2007.

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[1] France- Context in Artificial Intelligence: A survey.

[2] Bled, Slovenia, June 17 - 19, 2002. On the Potential Use of Mobile Positioning Technologies in Indoor Environments. MOBILE SERVICES

[3] Alcalá university. Mobile Telecomunications services. Antonio Portilla Figueras.

[4] http://www.neoteo.com/10-tecnologias-que-estan-transformando-al-deporte (Body area networks.

Interactive Multimodal Systems, Michael Johnston AT&T Labs-Research (MultiModal Interactive Systems)