# Sensors for AAL – what is actually missing?

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**Abstract.** Ambient Assisted Living (AAL) relies on continuously monitored and reliable data describing the vital status, the situation and the behavior of the elderly. Wearable, on-body sensing, computing and communication systems will outperform the 'ambient intelligence' approach, at least in the near future. Future wearable systems consist of a 'Smart Phone' as the personal computing and communication hub, and on-body sensors, mainly integrated in the clothes.

**Keywords:** AAL, Wearable Computing, Smart Textile, context recognition

## 1. Aging in Place – wishes and imperatives

According to the AAL Report[1], in the year 2020 the demographic change in the European population will result in approx. 21% people aged 65. The most of them intend to stay in their familiar environment as long as possible, despite increasing disabilities or chronic illness.

The increasing economic impact of aging at home has been documented repeatedly[1]. Here only one number: Assuming annual costs in a nursing home of 30k€/person and one million elderly only in Germany who can stay one year longer in their home, the savings potential amounts to 30 billion €/year.

Also stated in AAL Report[1], the elderly articulated their specific needs and requirements for an independent and self-conducted assisted living:

- Health (e.g. home care, tele-health care) and alimentation
- Safety/security
- Peace of mind
- Independence
- Mobility
- Social contact (e.g. communication, social life, social integration)

[1] Ambient Assisted Living - European Overview Report: Europe is Facing a Demographic Challenge, Ambient Assisted Living Offers Solutions. March 2006

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http://drops.dagstuhl.de/opus/volltexte/2008/1475

## 2. Instead of Smart Home: Smart Phone and on-body Sensors

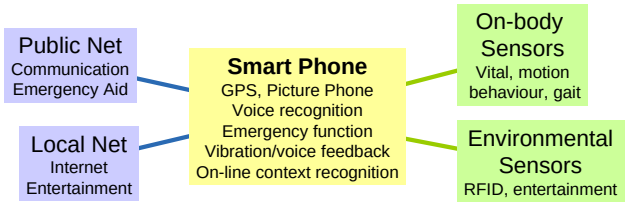
In the last ten years, the concept of a smart home has been investigated in manifold projects. It consists of a system of basic sensors being installed in home environment and monitoring the in-home activities. The sensor modalities span from RFID tags on household appliances to water flow and power meters, microphones, motion detection, pressure mats, video cameras. Experimental results have demonstrated the potentials of the smart home approach to detect and to monitor human activities[2].

The smart-home concept assumes - among others - distributed devices, a local network, local computing resources and an on-line connection to the outside world. Initiatives have been started to standardize the basic infrastructure for future smart home. But the scenario seems to be unrealistic that a significant portion of the elderly people can live in a smart home today or in the near future. Many elderly want to reside in the domicile where they are already living, partly since decades. And these residences are insufficiently prepared for smart home facilities.

**On-body and smart**

To fulfill the requirements mentioned above, systems have to be provided with access only to scarcely equipped homes. We propose a Personal Health Assistant PHA dedicated for elderly with moderate demands on the home infrastructure. As depicted in Fig. 1., it consists of a commercially available but slightly configured Smart Phone. On-body and environmental sensors are delivering data to the phone. Table 1 summarizes the relevant sensors and their capabilities in monitoring vital parameters and activities. The phone-internal computing capabilities enable on-line data processing, fusing and feedback procedures. The access to emergency support and medical services are provided by the connection to local and public nets.

**Fig. 1.** Architecture of the Personal Health Assistant PHA




*Pros and Cons*

This Personal Health Assistant concept shows several advantages:

- It is mobile, indoor as well as outdoor.
- It ensures a permanent connection to local and public nets.

[2] for example: http://smarthome.unibw-muenchen.de/en/, http://awarehome.imtc.gatech.edu/, http://www.icost2007.org/, http://www.intel.com/research/exploratory/digital%5Fhome.htm, http://www.cc.gatech.edu/fce/ahri/projects/index.html, http://www.futurehealth.rochester.edu/smart%5Fhome

- Adequate Smart Phones are already available on the market.
- Compared to home installation, the PHA will be cheap.
- The functionality can be customized and extended because of the
- standardized interfaces and software support.
- Privacy concerns can be controlled by encapsulating the personal data within the Smart Phone

But also drawbacks have to be considered:

- The PHA is not usable in all situations, e.g. in the shower
- At least at this time, the handling of the Smart Phone including charging is not very convenient.
- Elderly people with severe cognitive and fine motor impairments can not use such a system.

**Table 1.** Sensors for user's monitoring and detection modalities

| Sensor | Observation | Detection of |
|---|---|---|
| **Vital Parameters** | | |
| ECG | Heartbeat, Heartrate Variability | Cardio system, Excitation, stress |
| EMG (Electromyogram) | Muscle activity | Fear, excitation |
| GSR (Galvanic Skin Response) | Skin resistance | Fever, strain |
| Temperature | Skin and environmental temperature | Fever, weather |
| Blood oxygen | Cardiovascular system | Cardiovascular exposure |
| Respiration | Breathing frequency | Arousal |
| **Motion and Activities** | | |
| Acceleration | Limbs motion and position | Postures, movements, gestures |
| Gyro | Rotations, turns | Rotations of the body, or hands |
| Compass | Direction | Orientation |
| GPS | Localisation | Guidance |
| Microphone | Speech, noise | Speech detection, emotions, environment |
| Lightsensors (infrared, UV) | Illumination | Light sources, e.g. lamps, daytime |
| Humidity | Rel. Humidity | Weather, body activities |
| RFID | Localisation, tagging | Tracking, idenfication |
| **Communication** | | |
| WLAN, GSM, GPRS, EDGE, UMTS | Wireless communication | In-/outdoor Localisation, access to services and devices |
| Bluetooth, Zigbee | Short distance communication | Indoor, Localisation |

## 3. Required Technologies

The PHA concept relies on several components and services. Many of these technologies have reached a mature level at the market, some have to be improved or need major adaptations.

**Mature Technologies**
According to the ITRS roadmap[3], computing and communication devices will further improve their performances at decreasing power consumption.

Wireless communication is offering several approved standards, for the personal as well as for body area networks application, e.g. GSM, GPRS, EDGE, UMTS; Bluetooth for the 10m-distance and Zigbee for sensor networks in the 1m-distance.

Driven mainly by car, consumer and PC applications, miniaturized MEMS sensors have reached a market volume of $20 Billion in 2006. Tab. 1 also summarizes the available sensor functionalities.

**Enabling Technology: Smart Textile**
Acceptance and usability of the PHAs including the on-body devices require their unobtrusive integration into our daily outfit. At the moment, size, weight and inadequate connectivity of available devices still prevent their broad implementation in clothes. Research and development in the wearable computing field have provided a first series of wearable devices over the last decade. For example, textile electrodes woven in shirts measure the heart rate. Work is in progress to enhance the functionalities of fibers and fabrics. Nanotechnologies enable fibers with drug release as well as antibacterial, electrically conductive, sensory features. Fabrics can be equipped with active membranes, functional coating and protective functions.

## 4. Roadmap and Roadblocks

What are the main road blocks and problems to be solved? On the one hand, the acceptance of the elderly to wear smart clothes daily demands for a high level of wearing comfort and intuitive handling. On the other hand, co-operations between clothing manufacturers, electronic suppliers and retail have to be established to close the manufacturing, trading and maintenance gap. Furthermore, the PHA as a mobile and communicating device has to be embedded in the local and national IT landscape, involving net provider, private and public health services. Finally, because of the necessary interplay of many partners with partly conflicting interests the PHA has also to be integrated in the well established health organizations, including family doctor, caregivers, first aid organizations, drug makers, pharmacies, hospitals, and completing, the health insurances. Considering all these manifold challenges the ongoing projects in academia and industry indicate that we will see first commercially available PHAs in two to three years from now.

[3] International Technology Roadmap for Semiconductors, http://www.itrs.net/