# Human Computer Interaction in Context Aware Wearable Systems

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## 1 Introduction

Today access to computing power and communication has become nearly ubiquitous. Mobile computers and even mobile phones have computing power, storage and graphics capabilities comparable to PCs from a few years ago. With the advent of GPRS, UMTS, WLAN and other networking technologies high speed Internet access is possible nearly anywhere. At the same time an enormous amount of permanently updated information has become available online. In fact one can say that for nearly any situation there is guaranteed to be a piece of useful information somewhere on the network. This includes such trivial everyday things like restaurant menus and transportation delays but also information relevant to a variety of professional applications. The latter include building plans (relevant for rescue personnel), patient record (needed for example by emergency medics) and multimedia manuals (for maintenance and assembly work).

Thus in summary it can be said that in most settings mobile users have at their disposal both the relevant information and the means to access and process it. However currently they make only very limited use of it. In fact most people use their connected devices predominantly for conventional telephony, email access, scheduling and an occasional photograph. Despite a strong push by service providers accessing online information in a mobile environment is still the exception.

To a large degree the limited use of mobile connected devices can be attributed to the inadequacies of the current interaction paradigm. The most obvious problem is the user interface itself, which is based on standard desktop concepts emphasizing text, pointers, windows and menus. In addition network an application configuration and operation tend to be complex and time consuming.

Beyond these well known problems a new research direction has recently emerged: the development of proactive, so called context aware systems [1]. Such systems should automatically recognize the needs of the user and deliver the correct information at the correct time and place. Thus the idea is not just to provide a better interface, but to significantly reduce or even get rid of the need for explicit interaction. In the simplest case the context is just time and location.

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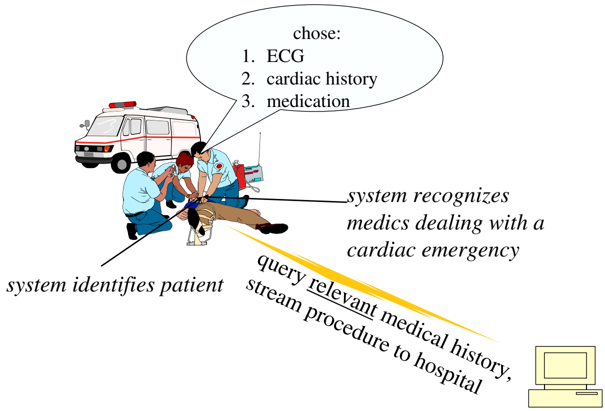


**Fig. 1.** An example scenario for context aware interaction

In more advanced applications it includes user activity (walking, standing, going to work, performing a particular maintenance task), environment state (e.g a meeting taking place) and background information such as the users schedule or habits.

## 2 Application Scenario

An example of context supported human computer interaction is shown in Figure 1. It envisions an emergency medical crew that attends to a heart attack patient on the street. Since time is critical the crew has little opportunity to access electronic information on the patient, look up advice on treatment, or transfer information back to the hospital. However if a computer system was able to automatically recognize what procedures the crew is performing and to identify the patient it could automatically deliver and collect the required information. Thus the system could contact a server, look up the medical history and automatically present the crew with information related to his cardiac history. For paramedics who might have problems dealing with a patient with a complex history action suggestions might also be provided. Finally the system might automatically record data from instruments and the paramedics actions and send them to the hospital to help prepare for the patients arrival.

Other health based scenarios [3, 4] include support of medical personnel in hospitals or lifestyle support for high risk patients and assisted living for the old and mentally handicapped. Other domains encompass office work [6] industrial assembly/maintenance scenarios [5], and consumer oriented systems. The office scenario has dealt with the automatic activity oriented annotation of multimedia meeting recordings. The industrial scenarios are part of the WearIT@Work project are car assembly, aircraft maintenance and emergency services (fire brigade) are being studied in real world environments.

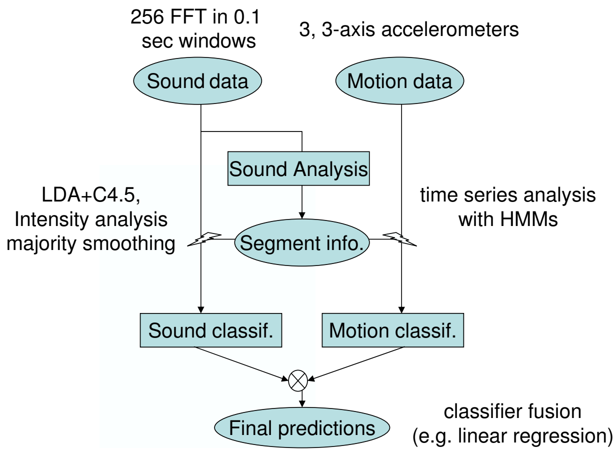


**Fig. 2.** Recognition method used in [5] to identify a set of wood workshop activities using three wearable 3-axis accelerometers and two microphones

What all the scenarios have in common is the fact that there are pieces of information available electronically that are not used today because finding and accessing them requires too much time and effort. A context sensitive system on the other hand can automatically identify what information the user needs, find it, and deliver it at the right moment and in the most appropriate form. Thus previously useless information suddenly becomes useful.

## 3 Recognition Methods

Context recognition, as defined in ubiquitous and wearable computing, builds on a many methods from classical AI and machine learning. However the problem that it addresses is significantly different from the classical AI vision. A typical context aware application can be described by a state machine. The states could be the individual steps of a surgical procedure or certain operations that need to be performed in an aircraft engine repair task. For each state a set of actions such as displaying a particular instructions or annotating a video recording is defined in the application. The aim of the context recognition process is to map a signal stream into this set of states. Thus context recognition neither aims to mimic human perception and cognitive processes nor does it really care about complex world models. In particular in the area of wearable computing much context recognition work refrains from using computer vision (with some exceptions e.g [7]) which is considered computationally to expansive and to unreliable in a mobile environment. Instead simple body worn sensors such as accelerometers, gyroscopes, ultrasonic positioning and microphones are used to track user's motions and his interaction with the environment. Since we assume the recognition to run on small embedded or mobile devices, strong emphasis is put achieving not just on optimal recognition rates, but also on the optimal tradeoff between recognition rates and resource consumption [2].

Figure 2 shows the principle of a recognition method used by our group in an experimental assembly scenario [5]. the scenario consisted of a series of procedures such as sawing, filing, taking something out of a drawer, drilling etc that were performed by 5 different subjects in a series of experiments. The subjects were outfitted with three accelerometers (one on each wrist and one on the upper arm of the right hand), and two microphones (one on the wrist and one on the chest). Based on the idea, that all activities can be associated with a characteristic sound the microphones were used to identify potentially interesting signal segments. To this end a combination of intensity analysis from the two microphones, simple sound recognition and smoothing was used. Time series analysis with Hidden Markov Models (HMM) was then applied to the accelerometer signals on the selected segments to classify the activity. The accelerometer classification was then compared with the sound classifier to weed out false positives and improve the overall accuracy.

Currently experiments with other sensors (e.g ultrasonic hand tracking, light sensors), instrumented environment and more complex scenarios are underway.

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