SMART AND AWARE PERVASIVE HEALTHCARE ENVIRONMENTS (SAPHE)
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INTRODUCTION
New telecare approaches to chronic disease management (CDM) within a home or community setting offer patients individually focused care and could substantially improve patient survival by assisting in the earlier identification of changes in a patient’s condition, and enabling more appropriate and timely interventions. The main objective of the SAPHE project is to address the need for a new generation of pervasive healthcare monitoring systems to allow early detection of deteriorating health by identifying behaviour and physiological changes over time. SAPHE will seek breakthroughs in a number of pervasive healthcare provision fronts:

- Miniaturised autonomic sensing with self-management and configuration
- Integrated local analogue signal processing and wireless data path
- Automated trust-based decision support and intelligent data mining and fusion

SAPHE is a collaborative project led by Imperial College London. Other project partners are British Telecom, Philips Research at Red Hill, Cardionetics, Docobo and the University of Dundee. Patient trials are carried out in collaboration with the Central Liverpool Primary Care Trust.

SYSTEM ARCHITECTURE
Constructing a pervasive healthcare environment requires the utilisation and integration of a significant number of data acquisition, communication, analysis and presentation components on the system and functional levels. Figure 1 shows the SAPHE top-level system architecture and linkages between major system sections.

HCI AND USER ENGAGEMENT
Being a pervasive healthcare monitoring system, SAPHE is able to serve several user groups such as professional caretakers and informal carers as well as the patients themselves. Consequently, a number of graphical user interfaces and visualisation tools have been developed to cater for different user needs. Figure 4 illustrates a typical interface used by professional caretakers to monitor patient activity and occupancy over time. Figure 5 shows a signal editing tool which enables engineers manage raw sensor data during sensor development and data analysis phases.

SAPHE COMPONENTS
To achieve smart patient monitoring, SAPHE makes use of a mixture of different sensing and data analysis modalities. Consequently, SAPHE architecture consists of three main components:

- Wearable sensing: provides patient specific monitoring of key physiological indices as well as contextual information (Figure 2)
- Ambient sensing: provides disease independent behaviour profiling and activity and posture recognition (Figure 3)
- Inferencing and decision support: performing long-term trend analysis and detection based on individual and pooled population data

FIGURE 1
Data of monitored individual(s) is collected from body-worn and home-installed sensors and streamed to the SAPHE network platform where data analysis is carried out. Resulting information such as observed deviation from normal behaviour or vital signs and warnings is fed back to perspective stakeholders (courtesy Nigel Barnes, BT).

FIGURE 2
The e-AR (ear-worn activity recognition) sensor developed at Imperial College is body-mounted wireless sensor capable of measuring patient motion and gait information as well as vital body signs such as heart rate, SpO2 and temperature.

FIGURE 3
(Top) Blob sensors are vision-based sensors that filter out scene background and capture the silhouette and motion of observed subject (Right) Ambient sensing is obtained by combining data from multiple blob sensors to compute subject’s posture and activity.

FIGURE 4
The SAPHE Visualisation Toolkit enables for creating web-based graphical user interfaces for different stakeholders. The toolkit can display patient location information for multiple patients and correlate it to other physiological/activity data.

FIGURE 5
Signal editing tool enables for interactive manipulation of sensor data with features such as log-scale display, import/export behaviour markers and multiple signals synchronisation.