Wearable Patient and Health Worker Monitoring: Opportunities for Improved Outcomes and Open Source Sensing

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Introduction

Monitoring systems have wide clinical application in health service provisions, for example, in rehabilitation, pre- and post-surgical assessment, monitoring of the acute medical patient and management of chronic conditions [1-3]. They also provide new opportunities for insights into the workplace activities, processes and stressors of clinical staff and health workers [4]. In prior work of The Quantified Outpatient Project (http://quantifiedoutpatient.com), a prototype 24-hour wearable and ambient monitoring system was developed, and opportunities and challenges identified [1]. A **new "Sense247" wearable and ambient monitoring system** is now presented. The underpinning vision is for a generic and expandable "core" sensing system to provide objective sensed recordings that are combined with quantified subjective reports, with the potential for beneficial **insights for both patients and health workers**.

Method - Clinical Prototyping and a Health Worker Design

A clinical prototyping methodology, with healthy participants and clinicians, was used to evolve the Sense247 wearable and ambient sensing system. The original on-body prototype [1] was **designed to be worn under short-sleeved hospital scrubs and health worker uniforms.** Participating clinicians were able to wear the system at work in the hospital (with all necessary permissions and following appropriate processes) as well as outside work.

The Sense247 sensing system comprises:

- **Daytime wearable sensing unit**: on-body accelerometry for Metabolic Equivalent Task, pulse, skin temperature and electro-dermal activity.
- **Night-time sensing units**: on-body unit as per daytime but with wrist accelerometry, and bedside unit for ambient light, temperature and sound-level.

For ease of deployment [5], the original prototype was designed for continuous 72-hr operation. Continuous recordings generate averages, minima and maxima in 1-minute, 15-minute, 1-hour and 4-hour intervals.

The Sense247 prototype is enhanced with USB rechargeable Lithium-Polymer batteries and Feather Cortex-M0 Adalogger data loggers with built-in charging circuitry and micro-SD data storage. Additional circuitry detects critical battery levels and automatically closes files to prevent data corruptions. Importantly, unlike many commercial monitors.

Pilot Prototype Use (by clinician),
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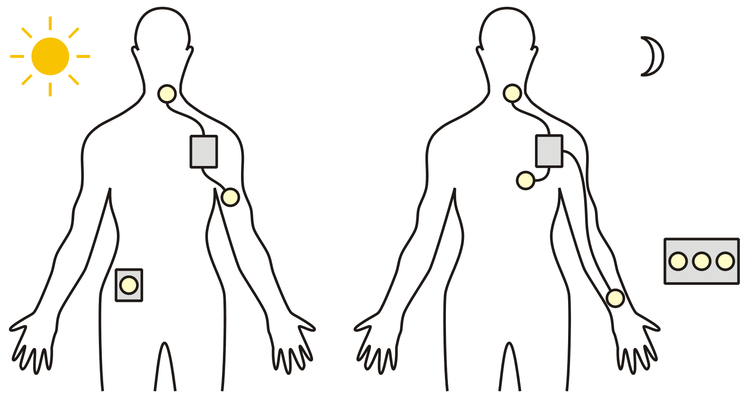


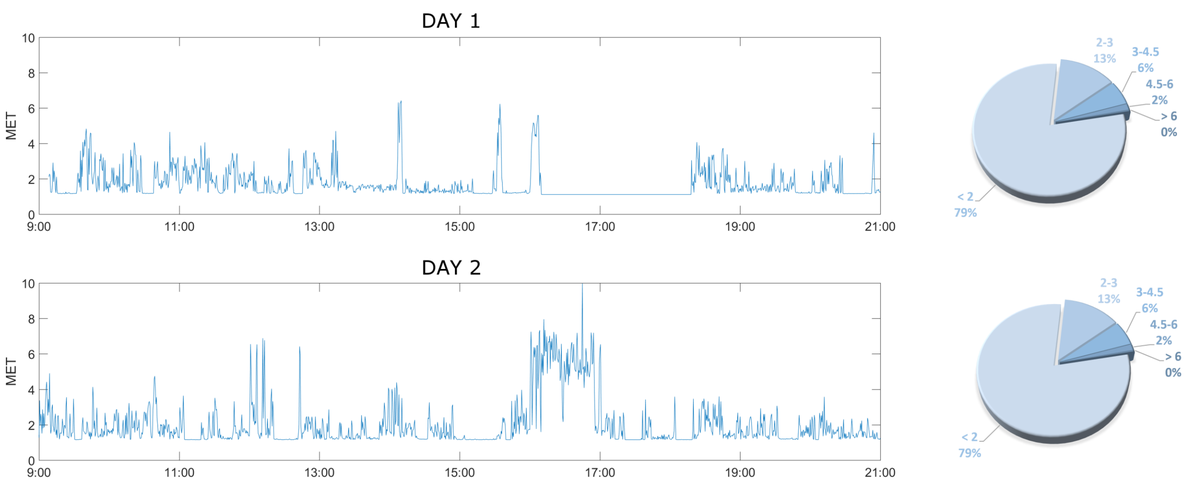
Sense247
- On-body daytime, night and ambient sensing

Compact Sense247 Data Logger
– Inside the on-body daytime logger
(processor, SD card, battery and accelerometer.)

Results

Assessments of system features and wearability, together with feedback from users and clinicians, informed improvements to the Sense247 design, benefiting wearability, usability and system performance, Improvements include the repositioning of sensors, **enhanced data integrity and more compact data loggers**,

As shown below, Sense247 enables **continuous Metabolic Equivalent Task (MET) monitoring down to sedentary levels**



Sense247 Daily Activity (MET) Recordings with Pie Chart Summaries

Conclusions

Whilst there are challenges in achieving robust, secure, ambulatory, multi-modal recordings from user-applied, hygienically-compliant systems, these challenges are not insurmountable, and the potential benefits are considerable, both in terms of improved insights and improved outcomes.

Discussion

24hr outpatient sensing has wide clinical application in rehabilitation, in the management of chronic conditions and, in pre- and post-surgical assessment. However, better detection of both low level activity and sleep is required than currently available in commercial activity monitoring devices.

Further Work

In addition to further use and testing, future research will focus on robust and compliant information security and clinical hygiene, and the potential for **open source delivery**.

The work of the Quantified Outpatient project can be found on-line at; http://quantifiedoutpatient.com.

References

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