Portable Vital Signs Monitoring through Electrical, Mechanical, and Optical Sensing and Precision Signal Processing

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Abstract— **Improving healthcare is a grand challenge that is universally important and the subject of directed innovations in technology. While improved imaging and diagnostics are important elements to diagnose and cure patients who are ill, it is in the area of prevention which offers the biggest hope for improvement. Personal health monitoring sensors are an essential ingredient in achieving this goal. Research work is ongoing to develop miniaturized versions of existing vital sign monitors, and great strides are being made in miniaturization, power reduction and connectivity which promise to make personal monitoring a reality. The grand vision now emerging goes well beyond the state-of-the-art in current clinical practice, and whole new classes of vital signs are enabled by advancements in sensors. In addition, with the advent of cloud computing, the ability to monitor large populations for totally new correlations is emerging, yielding new insights and actionable data.**

I. Introduction

Traditional paramters monitored on patients include, heart rate, blood pressure, oxygen saturation level and core temperature. Historically, these were measured at intervals using bulky instrumentation. Modern semiconductor technology has premitted the miniatuization of such systems to the point where they can now be worn on the body. This offers tremendous advantages, not only in convenience for the patient, but also in enabling automatic continuous monitoring, data collection, with considerable savings in staff costs. Two key examples would be ECG measurement, and activity monitoring. However, much remains to be done, for example develop relaible blood pressure and core temprature measurement in a convenient body-worn format.

II. The progress to date

Much progress in miniaturization has been made to date to take large instruments into small form factors. As an example, ECG measurement has recently made tremendous strides. The ADAS1000, from Analog Devices, for example, provides a complete solution in a single chip. It provides clinical-grade digitization of multi-lead ECG signals and contains advanced features such as pace pulse detection and integrated respiration measurement.

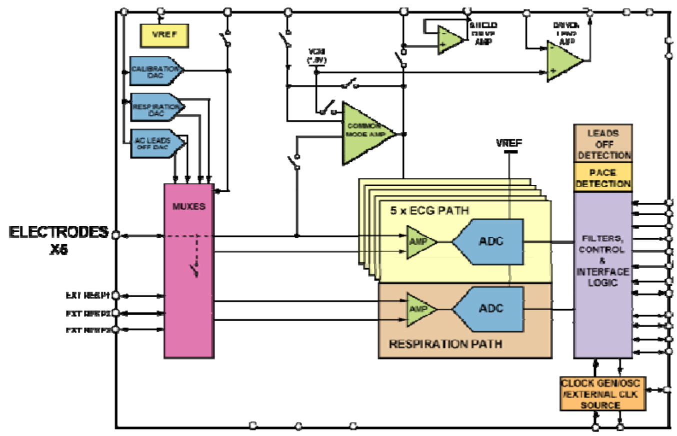

Figure 1. Example of a complete ECG system (ADAS1000)

III. The Open challenges

Grand challenges in vital signs monitoring pose key questions: How can parameters such as blood pressure be measured in a convenient body-worn format? Similarly, measuring core body temperature to acceptable clinical standard has proved to be a difficult challenge. Are there totally new parameters beyond the clinically-accepted set, which can be easily monitored, which can increase the accuracy of diagnosis as well as predict health deterioration? Galvanic skin impedance for stress monitoring, and pH measurement for fatigue estimation are showing promise, but there may be many others.

The future holds great opportunities for data analysis and inference for clues to the previously unknown. Analogous to the invention of the microscope and the stethoscope, the ability to see with finer detailed resolution the state of the body, we anticipate that correlations are likely to emerge, both across populations and for individuals. The emergence of precision and pervasive vital signs monitoring generates opportunities for discovery and learning that is a grand challenge worthy of a global and interdisciplinary effort.

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