Vital Sign Monitoring and Biometric Data Processing

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Introduction

Vital sign monitoring and biometric data processing involves more than taking measurements. Health monitoring encompasses the whole process between collecting biometric data to visualizing the data in a consumable format. The process includes taking vital signs, digitizing the signals, transmitting packets containing the medical information, and delivering the data to healthcare professionals in an easy to interpret way [9]. Humans require data processing in order to understand, recognize patterns, and draw conclusions. Computers retrieve, manipulate, or identify information from raw data [8]. Each combination of raw data and information required by the user requires varying amounts of data processing.

Humans have been monitoring vital signs since 1625, when Galileo published methods of measuring body temperature [3]. Wireless health monitoring has taken off in recent years with the invention of personal health devices, such as FitBit (invented in 2007). Devices come in many forms, ranging from wristbands to patches to all kinds of wearable tech.

Considerations

Technical Considerations

Health monitoring systems generate significant network traffic and require storage. The amount of storage necessary depends on both the amount of raw biometric data as well as the amount of required additional information. A vital sign monitoring system needs both live data and contextual information, such as the test conditions and the patient's health history. The more contextual information, the more storage the system takes up. Transmitting only differential vital signs instead of whole vital signs can solve the problem by limiting the amount of storage required. Differential vital signs only look at the change in the vital sign since the transmission or a reference value.

Network traffic can affect the data's reliability, as well as delay and latency. Compressing the traffic offers one solution. However, this requires increased processing and could introduce packet delays and errors. Other solutions for network traffic management include admission control, prioritizing, and even using multiple wireless networks.

Patient and User Considerations

Health monitoring and processing pose several important considerations to the designer of the technology, the user, and the patient.

As previously mentioned, all health monitoring systems must include contextual information, including the patient's background and the test conditions. A comprehensive system accounts for the patient's physical health before the test as well as any other relevant factors, such as White Coat Syndrome. The testing environment and presence of a doctor often affects a patient's vital sign response, called White Coat Syndrome. Although a healthcare professional should work to minimize the effect by creating a comforting environment, the health monitoring system must consider how a stress response could alter the data.

Healthcare professionals must conduct vital signs and other health monitoring in an expected and repeated testing environment. This includes but is not limited to, consistent temperature, light, time of day, and food and beverage consumption of the patient prior to testing [4].

Quality of Service Requirements

The patient and user needs to specify the Quality of Service requirements, or QoS requirements, for a health monitoring system. The engineer must design a system that meets these requirements. The QoS requirements dictated to the engineer must include patient centric requirements, network centric requirements, and healthcare professional centric requirements.

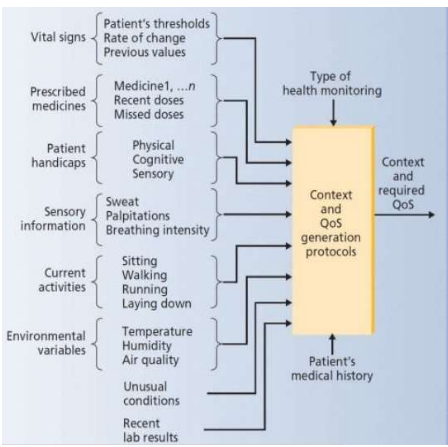

Figure 1. Context and QoS Generation Protocols [7]

Patient centric requirements include message delivery reliability and the end-to-end monitoring delay.

Network centric requirements define the message throughput, which is the amount of material through system. The network centric requirements also include the number of supported patients.

Healthcare professional centric requirements detail the number of messages a healthcare professional will receive and process. This depends on the number of patients, number of messages per monitored event, and frequency of monitoring. The healthcare professional centric QoS requirements also specify the number of correct medical decisions per the number of messages received and processed [2].

Processing

Processing turns raw data into a consumable format that visualizes the information to the user. There's a variety of ways of processing data. When processing data, the system should consider the raw data, desired information, and user interface.

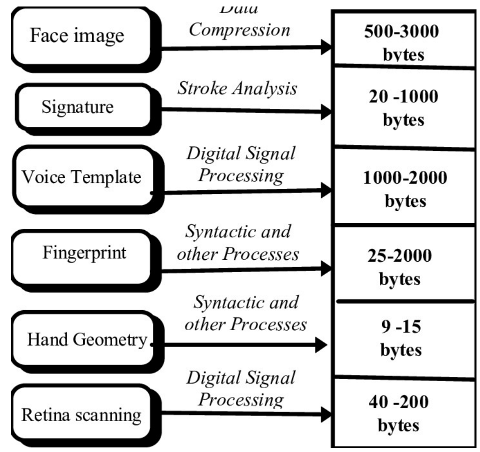

Figure 2. Requirements for Various Biometric Data [6]

As with most raw data, vital signs and other biometrics require processing. A standard processing technique consists of building filters. Implementing a high pass filter, in either hardware or software, commonly occurs in data processing to minimize high frequency noise. A processing solution could implement additional filtering to eliminate other noise (60Hz is a common culprit) or isolate certain frequencies. Processing can employ simple filters, such as bandpass or band notch filters, or more complex filtering techniques, like Chebyshev or Butterworth filters.

Processing manipulates data to better recognize patterns or anomalies. Linearizing data can identify a steady trend. Viewing data in the frequency domain can provide valuable insight.

Passive monitoring records vital signs and transmits data to analyze later, while active monitoring generates and analyzes live vital signs and contextual information before transmitting to a healthcare professional. Depending on the readability of the initial measurements, computing power of the transmitting and receiving device, and any network restrictions, a situation's biometric data processing may benefit from either a passive or active monitoring system [7].

Processing biometric data requires contextual information. Physical movement might cause steady change in signal. A stressful environment might lead to a rapid change in a patient's vital sign. Processing can account for these situations and find trends and anomalies indicating health information, but only if the health monitoring system provides context before processing [1].

Conclusion

Vital sign monitoring provides helpful data to individuals and necessary information to healthcare professionals. The user must consider the intended conditions and desired results when choosing a health monitoring system. An engineer must design with technical, patient, and user considerations in mind, when building the system. Health monitoring systems must incorporate processing of raw data, adjusting what the processing should comprise of and when the processing should occur based on the user, the test conditions, and the raw data.

If designed properly, a health monitoring system can facilitate data collection and intuitive data visualization.

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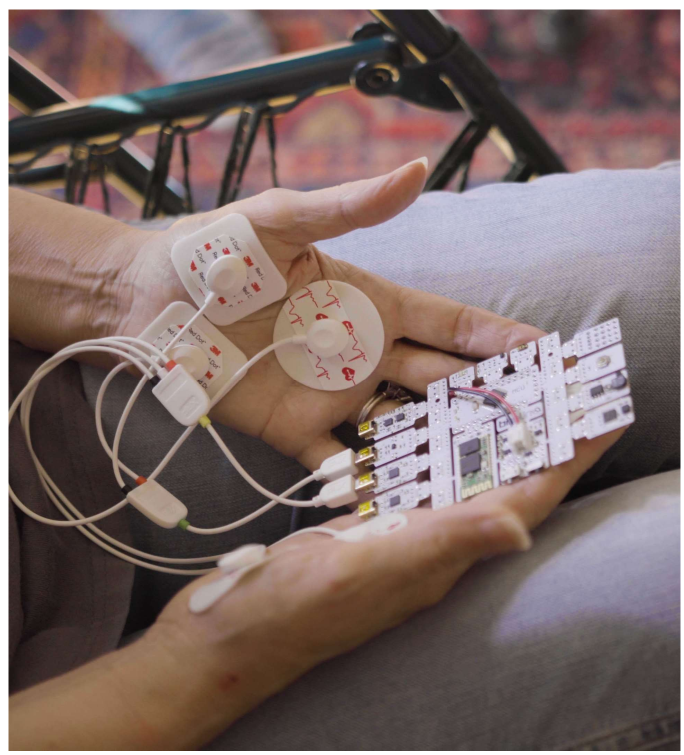

Figure 3. ECG and EDA monitoring [5]