Study of Real-Time Cardiac Monitoring System: A Comprehensive Survey

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ABSTRACT

Today’s healthcare technology provides promising solutions to cater to the needs of patients. The development of wearable physiological monitoring system has reached home-centric patients by ensuring faster healthcare services. The primary advantage of this system is activation of alarms to alert the specialist in a nearby hospital to attend to any sort of emergency. Specifically, cardiac-related problems need special attention when a 24-hour Holter monitors ECG signals and identifies the level of abnormalities under various circumstances. Although several brands of Holters exist in market, there is a huge demand for digitized Holter recorders. These recorders can simultaneously analyse cardiac signals in real time mode and store the data and reuse them for next 24 hours. As home-centric based wearable cardiac monitoring system gains much attention recently, there is a need to design and develop a cardiac monitoring system by establishing a trade-off between the required clinical diagnostic quality and cost. This research study highlights a comprehensive survey of various cardiac monitoring systems under wire, wireless and wearable modes. This provides an insight into the need of the hour in bringing a cost-effective wearable system. The study provides an insight of the technological aspects of the existing cardiac monitoring system and suggests a viable design suitable for developing countries.

KEYWORDS
Cardiac Activities, ECG, Holters, Physiological Monitoring, Wearable

INTRODUCTION

Due to quality of lifestyle today, there is a huge increase in percentage of young age group (say 18 to 30 years) prone to chronic cardiac-related diseases. Electro cardiogram (ECG), which reflects the continuous cardiac activities, plays an important role in providing the required clinical diagnostic information for the cardiology community. In the last two decades, Holter recorders have been used to

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monitor continuous cardiac episodes for 24-48 hours (Erik et al., (2015)). Their dynamic non-invasive
monitors store the recordings and are validated later by a cardiologist for arrhythmias detection. Attempts have been made to design digital Holter recorders to overcome certain limitations. Due to
the severity level of chronic cardiac-related disorder, there is a huge demand to recognize the related
episodes in a real-time mode and to raise an alarm for the patient to consult a specialist immediately.
On the other hand, these episodes can be transmitted in a real-time mode through cloud server and
the specialist in a nearby hospital can direct the patient based on the severity level. Taking this trait
into account, wearable physiological monitoring system has gained much attention in the recent years.
Systems that make use these technologies are being introduced in market then and there.

Although wearable technology which is closely associated with home-centric based health care
delivery gained popularity, its huge cost restricts its affordability to resource-constrained population.
This research study provides an insight into real-time cardiac monitoring system, a comprehensive
survey on various systems and signal processing techniques reported in the literature. The salient
features and limitations of cardiac monitoring systems are also compared. Finally, a real-time cardiac
monitoring system is proposed to overcome all these limitations.

CARDIAC MONITORING SYSTEM

Recent developments in the miniaturization aspect of sensors has created a huge impact on the
wearable physiological monitoring related studies. Such sensing device ensures portability with less
power consumption as well as effective energy utilization. The primary advantage of such systems
are continuous monitoring of the signals in real-time by clinicians in a monitoring station along with
activation of alarms during critical conditions.

In general physiological sensors, such as ECG, demand large energy due to high sampling rate and
resolution and also impose limitations due to reduced user wearability. Holter systems are available
for patients with cardiovascular diseases to record their cardio activities as demonstrated by Laze et
al (1997). In 2001, there has been a notion of telemedicine using mobile phone by NegoslavDaja et
al and with power efficient algorithms for Paroxysmal Atrial Fibrillation as proposed by Schreier et
al. (2002). Gouaux et al. (2002) proposed a smaller and feasible device for telemedicine. However,
it was still insufficient due to lack of processing of raw ECG signals in their devices.

Wireless sensing technology in the recent past decade can enables the healthcare delivery in a
better manner and helps in monitoring of patients who are at risk. Although these sensor nodes offer
potential low-power operation, the need to limit battery volume to enable a compact package and
the need for supporting energy-intensive sensing systems require an energy management method
(Winston et al., 2008). This must optimize the operation of sensors and other components further
to meet measurement demands while minimizing energy. Energy usage of sensor nodes may be
reduced by activating and deactivating sensors according to real-time measurement demand. For
better brevity, Table 1 emphasize the various cardiac monitoring system reported in the literature.
The report comprises of engineering principles, sensors used, design factor, signal processing and
communication modalities adopted and advantage/limitations of each technique.

Table 1 shows a brief report of related literature.

RELATED LITERATURE

Cheng wen et al. (2008) have designed an ECG telemonitoring system based on a mobile phone
platform. The signals were identified by the patient wearing Holter unit and abnormal heartbeats were
transmitted in real-time system using GPRS or MMS. The Holter information through GPRS was
then used to locate the patient in emergency. Real-time ECG classification algorithm was executed
by a dual-core processor to identify abnormal beats with classification accuracy in the order 98%.
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