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Original

Review and investigations on future research directions of mobile based telecare system for cardiac surveillance

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Abstract

Tele-surveillance is the method of patient monitoring, provided that medical practitioner and patient are separated by a large distance and it also involves inaccessibly monitoring the patients who are far away from the health care provider. This article talks about a few of the vital challenges and opportunities of communications research in the areas of Telemedicine and E-Health. Especially, we focus on some of the key communications challenges for understanding interoperable and future-proof of Mobile Tele-health systems, need for doing research in this broad area with the help of statistics collected from various health organizations and how drawbacks of some existing technologies can be solved. We have overviewed this telemetry technology and present the state of the art on each aspect. Some research problems that need to be solved in this area are also described.

Keywords: Biomedical communication; Biomedical signal processing; Biomedical telemetry; Electrocardiography; Healthcare and Telemedicine

1. Introduction

Tele-health is a fast-growing inter-disciplinary area, in which electronic information and communication technology is used to deliver health and medical information and services over large and small distances (Suman & Prathyusha, 2012). Tele-health includes telemedicine, which offers empowerment, a better quality of life, and reduced cost of care for patients with chronic disease, such as cardiovascular disease, diabetes, chronic respiratory diseases, and cancer (Donoghue & Herbert, 2006). However, Tele-health also includes applications for healthy people, who want to maintain or improve their health. Mobile Tele-health systems are becoming more important all the time, especially in the care of patients that are isolated or traveling, far from a reference hospital. These systems must be embedded in low cost, small devices with low power consumption, and should have an interface that is usable by the patient. Incorporating technologies such as Bluetooth and Global System for Mobile (GSM) allows the wireless transmission to health centers (Kumekawa, 2000).

The application of wireless communications is already quite common in hospital and emergency settings (Gao et al., 2008). Some examples of medical equipments include heart, blood pressure and respiration monitors (Kumekawa, 2000). In addition, emergency medical service companies are, or will be, important users of telemetry and other wireless technology (Gao et al., 2008). In vehicles, telemedicine equipment can be as simple as a cell phone or a laptop computer with two-way videoconferencing capabilities. More sophisticated vehicles offer mounted video cameras that the hospital emergency physician can pan and zoom remotely (Gao et al., 2008).

Another very common form of telemedicine that has generated a lot of interest in the networking community is remote patient monitoring (Rajan & Sukanesh, 2013a), which facilitates an improved quality of life for the patient by enabling the measurements to be made anywhere there is a phone connection, and by reducing the need for routine trips to the clinic. While such systems have demonstrated positive outcomes, e.g. in terms of reduced number of trips to the emergency room (Kumekawa, 2000), wireless monitoring promises further improvements by providing continuous monitoring, patient mobility, and improving patient compliance with frequent and better quality measurements (Kumekawa, 2000). When appropriate health professionals cannot be physically present to diagnose patients, telecommunications technology can be used to connect these professionals to those in need of their expertise (Qureshi et al., 2005). In hospitals and homes, telemedicine has been shown to reduce the cost of health-care and increase efficiency through better management of chronic diseases, shared

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health professional staffing, reduced travel times, and fewer or shorter hospital stays (Xiao et al., 2000).

We focus on using telemedicine to improve outcomes when dealing with acute incidents involving critical care patients. By relaying real-time telemetry and video from ambulances, we hope to provide expert opinions on complex injuries, and to aid the inhospitalities in better preparing themselves for incoming patients. In many situations, the timely application of an appropriate therapy is of critical importance, and mobile telemedicine can help (Xiao et al., 2000). Patients with heart arrhythmia usually need to be monitored and controlled in hospital for one to several days. These patients are treated to reach on normalizing their heart arrhythmia or achieve an average heart frequency (Qureshi et al., 2005). Sometimes it is necessary to monitor some heart patients in longer periods of time to provide more certain documentation for the treatment's correctness, but the patients often are released from the hospital to give the priority to other heart patients on the waiting list, whom need to be hospitalized immediately. Furthermore, some of heart medicaments are effective only when the patients have minimum activity, namely, when they are hospitalized, but these medicaments are not so effective at home, where the patients have normal or higher activity level. If the ECG or heart rate crosses the threshold set by the doctor depending on the patient, a Short Messaging Service (SMS) is generated by Microcontroller unit automatically and it will be transmitted to the doctor's mobile through the GSM modem. The SMS gives the ECG and heart rate of the patient so that medical aid can be rushed to the spot.

This paper describes the issues in developing a low cost, portable system with wireless transmission capabilities for the acquisition, processing, storing and visualization in real time of the heart rate to a mobile phone and how the problems can be solved.

2. Background

National Health and Nutrition Examination (NHANES) that surveys that the prevalence of low coronary heart disease risk, overall and by sex in the year of 1971-2006 stated that 80% of people are affected. Survey of 2009-2010 has showed the statistics of diabetes mellitus awareness, treatment and control. Also diabetes can lead to cardiovascular disease, blindness and kidney failure. The treated and controlled occupied a percentage of 25.8%. Then the treated and uncontrolled occupied a percentage of 43.2% and not treated but aware was 8.3% and not treated and undiagnosed had 22.7% (NHANES, 2009-2010). World Health Organization (WHO) annual statistics report includes information from 194 countries on the percentage of men and women with raised blood pressure and blood glucose levels. Another important issue is obesity. In regions of the world, obesity doubled between 1980 and 2008 (as per the statement from Dr. Ties Boerma, Director, Department of Health Statistics and Information Systems, WHO). Today, half a billion people (12% of the world's population) are considered obese. Highest obesity levels are in the WHO Region of the Americas (26% of adults) and the lowest in the WHO South-East Asia Region (3% obese).

Heart attack (also called myocardial infarction) is the death of the heart muscle due to loss of blood supply caused due to blockage in one or more of the coronary arteries supplying the heart. Heart disease is the leading cause of death in the United States. More than a million persons in the United States have heart attack each year and about 50% of them had passed away. The risk of heart attack in both men and women are almost equal, with women accounting for nearly half of all heart attack deaths (Table 1). According to a projection by the World Health Organization (WHO) and the Indian Council of Medical Research (ICMR), India will not only be the heart attack capital but also the capital of diabetes and hypertension by 2020. People having heart disease had increased from 1-2% to 3-5% in rural India and from 2-3% to 10-11% in urban India. This represented an overall increase of 300 percent over the past 30 years. In 2006 (baseline data for the 2020 Impact Goals on Cardiovascular Diseases), age-standardized death rate from all cardio-vascular diseases (CVDs) was 262.5 per 100,000. Death rates from heart diseases and other cardiovascular causes were 43.6, 200.2, and 53.9 per 100,000, respectively. Data from NHANES 1999-2010 reveal that, overall, 8.1% of Americans self-reported having some type of CVD. Among those with CVD, risk factor prevalence, awareness, treatment, and control were variable. Nearly 37% were current smokers or had quit for less than 12 months. From 2005 to 2010, the Data from the NHANES indicate that 33.5% of US adults ≥ 20 years of age have hypertension. The prevalence of hypertension is nearly equal between men and women. African American adults have among the highest rates of hypertension in the world at 44%.

Table 1
General Statistics (from WHO, ICMR) of Heart Attacks for Different Age People.

Age	Criteria	Statistics of Men	Statistics of Women
Does not matter	Vulnerability to heart attacks	Men are more vulnerable to heart attacks as compared to women More than 420,000 men are hospitalized for heart attacks every year	Though women are less vulnerable to heart attacks, deaths due to heart attacks are more in women as compared to men. Around 350,000 women are hospitalized for heart attacks every year
40 and above	Death after first heart attack	In this age group, around 18% deaths occur after the first heart attack	In this age group, around 22% of women deaths occur after the first heart attack
45 and above	Death after first heart attack	In this age group, 32% deaths occur after first heart attack	For women in this age group, the fatality rate is around 42%
45 and above	Risk of heart attack	In men, risk of heart attack increases greatly after 45 years of age	In women, risk of heart attack increases greatly after 50 years of age
64 to 70	Average age for first heart attack	Average age for first heart attack in men is 64	Average age for first heart attack in women is 70