Review on Energy Harvesting and Data Collection

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Abstract. Energy harvesting is important in the case of recharging or repayment of battery. Energy harvesting means that energy is delivered from external sources like solar energy, thermal energy, kinetic energy and wind energy. Two or more sensors are attached to a body forms Body Sensor Networks (BSNs). BSNs are mainly focused in healthcare domain. It allows patients, physicians, caregivers, scientists, etc. It is useful for continuous monitoring of patients (Diagnosis patients, treatment of chronic obstructive pulmonary disease patients and other health conditions). Doctors made interaction between the data collected body sensors and personal digital assistant (PDA). Disadvantage of existing system is batteries cannot be easily replaced, must be near a transmitter, expensive, etc. Energy Harvesting and Data Collection (EHDC) focuses two types of energy harvesting techniques such as solar and thermal energy harvesting and two types of data collections are used: indoor and outdoor data collection. Harvested energy can be predicted by using Kalman Filter. EHDC provide mobile healthcare services and does not need recharging.

1. Introduction
Body Sensor Networks (BSNs) are cyber-bodily sensor structures which can be able to amassing, processing, and speaking physiological statistics from the body and environmental statistics from the region surrounding it. BSNs overcome the weakness of traditional remote hospital system. Recent technology provide full continuous monitoring of patients beyond the clinic and also overcome the drawback of limited battery life time or must be replace or recharging battery [26]. Power harvesting is vast answer for the limited battery life time of body sensor community. Three stages of healthcare monitoring system are sensors, data hub and hospital system. Although there are many applications for BSNs such as tracking, scientists, remote patient monitoring in healthcare system [27]. Researchers have necessity methods of separate magnificent supervise such as self-restrained unmixed-relate and abode hardness technologies to vestige symptoms and become recommendations to patients or to occur when inevitable. Sometimes, patient self-report tends to be imprecise because it can be difficult for patients to accurately represent their own symptoms. BSN network provide an alert message to the hospital system, if due any changes in vital parameter.

Automatic recognition of daily living activities can be primarily classified in two-wearable and non-wearable system. This paper focused on two types of energy harvesting technique- solar and thermoelectric energy harvesting. Data collection are done both indoor and outdoor condition [27].
2. Body Area Sensor Network (BASN)

A body sensor network (BSN) is also known as wireless body area network (WBAN) or a body area network (BAN) [1]. BAN devices may be fixed in the body, or may be attend the device which human can move in distinct places, in cloths pocket, by hand. That is it can fix anywhere in the body. All body sensors unit (BSU) are controlled by a single central control unit (CCU). Initial application of BAN are originally in the hospital system for the continuous monitoring of patients suffering from chronic obstructive pulmonary diseases (COPD) such as arthritis, asthma, cancer, diabetes and some viral diseases such as hepatitis C and HIV/AIDS [2]. Body sensors are placed on a patient body, it can alert the hospital system, even before they have a heart attack or any emergency situation, through measuring changes in their vital parameters. Other applications of BAN are include Tracking, sports, Scientists (measuring body variations) military, or security. The six operational characteristics in BASN- sensing, signal processing, communication, caching, feedback control and energy harvesting [1].

![Figure 1. BASN node architecture](image)

As figure 1 shows BASN node architecture. The main components are sensors, energy source, transceiver, storage, actuator, and sensors. Sensor is a device used to detect events or detect changes in to environment and send information from one to another device. Sensors are classified in to three categories- physiological sensors, biokinetic sensors, ambient sensors. Physiological sensors capture signal from sensors are placed on the patient body. Different physiological signal processing (PSP) have been developed such as electrocardiography (ECG), electroencephalography (EEG) and electromyography (EMG). Biokinetic sensors measurement acceleration and sudden rank of rotation trace from human motion. Ambient sensors metric environmental phenomena, such as dampness, knowledge, correct squeezing horizontal, and mixture. Aggregator is used to combining data from multiple sensors on the body and act as bridge between the nodes higher level infrastructure and provide user interface. long term information series regularly needs no actual-time aggregation, on-node storage is an inexpensive solution for archiving statistics, thereby growing battery lifestyles. Disadvantage of lithium based battery is high energy density, limited capacity and recharge/replace battery. To overcome these use super capacitor or carbon nanotube. It leads to improve the battery capacity. Wireless transceiver can reduce power consumption by data rate extracting only the essential information and limited transmission range can reduce power consumption. Automatic recognition of daily living activities can be broadly classified in to two- wearable and non-wearable system.
3. Wearable System

Wearable system classified into two categories: wired wearable sensor network and wireless sensor network. Its design depends on low cost, intelligent, tiny and lightweight sensors that can be placed on the patient body. Wearable sensors are proposed for automatic recognition of daily living activities [29].

Figure 2. Wearable wired BASN

Figure 3. Wearable wireless BASN

Figure 2 and 3 shows primarily three parts body area network, data aggregation or communication part and hospital system. Figure 2 defines two or more sensors are attached to the body and that are interconnected to a common control unit. CCU which control overall sensors. If the connection between the BAN and CCU is a wired connection then the sensor signal is transmitted only the limited distance, that is signal is send to the local PC [28]. Figure 3 shows the wearable wireless connection of BSN. The WBSN are connected to the CCU through without any wired connection (ie, wireless connection). Two transmissions are possible, first the transmission between WBSN and CCU through ZigBee or Bluetooth and the next transmission from CCU to hospital system. The example of wearable wired system is take blood pressure measurements. Blood pressure sensors (Physiological sensors) are used and the corresponding result is obtained in local PC. Commonly used wearable wireless system is wrist band. Human beings are warm blooded, they can be used as a heat source attached to the skin. Small body temperature sensors (physiological sensors) is attached to the wrist band and monitor the temperature of a body [4].
4. Non-Wearable System
Non-wearable sensors are used for continuously monitor of patients activity of daily living (ADL) [29]. If any abnormal situation (eg: Heart Attack) occurred an alert message is send to receiver station (eg: hospital system) based on the changes in vital parameters. Non-wearable sensors include self-report instruments and devices installed in the home (eg: cameras, thermal sensors, infrared sensors). These devices like cameras or sensors are installed in to the home or office and automatically recognize the daily living activities of a human being like walking, standing, sitting etc. Non-wearable devices are under the category of ambient sensors. Ambient sensors are used to measure the environmental parameters (eg: temperature, humidity etc.)[1]. Ambient sensors are fixed sensors which are communicate through fiber optic support around 20-30m.

5. Design Challenges
while designing self-powered sensor system sources which includes sun, thermoelectric, piezoelectric, RF, wind, etc. have been explored. Regarding self-powered BSNs availability is a main factor, however also wearability has excessive impact when dening the source for use based totally on these considerations for self-powered BSNs sun, thermoelectric and piezoelectric strength harvesting are commonly selected as the power supply alternatives. Gaps from overview is energy harvesting techniques focused on out of doors conditions only most commonly used lithium based battery has limited capability and want recharge or replace frequently. To overcome this solution use supercapacitors and carbon nanotube [1].

6. Energy Harvesting and System Wearability Optimization
Two types of energy harvesting techniques-solar energy and thermoelectric energy harvesting. Existing system solar energy is harvested from outdoor condition only. This paper focused on solar energy is harvested from both indoor and outdoor condition. In the case of solar cell, it is clear that the ambient illumination level defines the maximum amount of harvested energy, but it also has been studied how the angle of incident of light impacts the efficiency [27]. Sensors are attach to the patient body in some manner, then both illumination and angle of incident changes when a person move around during a typical day. The AM-1417CA solar cell and NOA 1212 sensor are attach on the body. Solar cells are directly captured heat energy when the molecules are collide, chemical reactions occurred. Chemical energy convert in to electrical energy. Similarly for the thermoelectric generator(TEG) temperature difference across the device determine the available power. TEG is also known as seedback temperature is a solid state device that convert heat energy in to electrical energy. Sp5424-04Ac thermoelectric generator is used and a heat sink was attached to the cold side of TEG. A MAX6605 body temperature sensor is placed inner side of TEG.

7. Energy prediction model
Harvested energy can be predicted by using kalman filter. Prediction usually mean that amount of energy harvest from sources. Kalman filter is used to estimate the observation and to predict harvested energy. Kalman filter depending parameters are two types Environmental and behavioral parameter and harvested energy. Environmental parameter consist of light intensity, temperature difference and activity level. Harvested energy parameter depends on solar energy and thermal energy.

8. Graphical rule editor
Emergency services provide by using graphical rule editor. Figure 4 shows two measurements. If the current measurement value are compare with predefined set value. For example Figure 3 shows current pulse reading is greater than predefined set value of pulse (120) and if the current
blood pressure (BP) reading greater than predefinly set value of BP (130). If exceed the value then corresponding alert or message is send to the emergency service.

9. Conclusion
To improve the quality of life for the elderly persons with chronic diseases, propose a small cell based sensor network for home monitoring. Two types of energy harvesting techniques are used solar and thermolectric. Data collections are done in both indoor and outdoor conditions. The EHDC platform is designed to characterize the relationship between environmental and human behavioral conditions and real-world energy harvesting dynamics\cite{27}. Human beings are warm-blooded, therefor TEGs are attached to the skin and can be used as a heat source. With this consideration for people to wear these devices, it is common to attach TEGs on the wrist or arm. The feasibility of batteryless operation of wireless sensor nodes using solar energy harvesting at locations where the amount of solar radiation is severely limited and seasonal variations are large. Kalman Filter (KF) based model to predict the harvested energy based on environmental and human behavioral parameters. KF is an estimation model that combines several previous observations to produce an estimate for the desired unknown as it is presented in \cite{6}. The proposed model was adapted from this work and consists of state process and measurements by sensors; the state process is dened by the environmental and human behavioral parameters since they represent the physical principle of self-powered energy harvesting while the measurement values are acquired from sensors.

10. References
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