REVIEW ON RECENT WEARABLE TECHNOLOGY FOR RESPIRATION MONITORING

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Abstract : Respiration is one of the most vital process of human body. The advancements of the technology had improved the way of detecting the rate of respiration through wireless technology. The wireless technology mainly uses wearable and portable sensors which have its unique featured properties in monitoring the respiration rate. The paper describes the recently discovered wireless technology that has improved the continuous monitoring of respiration rate based on the angular velocity, flexible capacitive pressure sensor and non-contact capacitive electrode. The working principle of all the determined technologies varied based on the types of sensors used to monitor the respiration rate. Various Effective wireless technologies used for monitoring respiration rate is illustrated and compared.

IndexTerms **- wearable technology, respiration monitoring, inertial sensor, flexible capacitive pressure sensor, non-contact capacitive based electrode.**

I. INTRODUCTION

Monitoring of vital parameters is mainly defined to analyze the physical state of the patient. The development of current technologies has improved the field of healthcare to a greater extent. Respiration monitoring is necessary criteria in Patient monitoring system. Respiration acts a vital sign that can be stated as the process of exchange of gases through mechanical actions. Respiration is one of the important parameters of human bodies which is monitored continuously to detect sleep disorders (i.e., sleep apnea), asthma which is common respiratory diseases and all kind of critical conditions that is related to respiratory tract or not. Different techniques and equipment's are designed for continuous monitoring of the vital parameters. Monitoring the vital parameters of human body accurately in motion or during daily activities are challenging tasks in present life [1].

Respiration monitoring has advanced by development of noninvasive monitoring techniques. These techniques involve the study of gaseous level in the blood, capacity of the lung and its compliance, perfusion rate of gases, analysis of ventilation process and so on. Noninvasive methods are designed to be more user-friendly and can be advanced by undergoing certain advancements in the design. Respiration and other parameters can be monitored using wearable technology.

Wearable the term indicates the devices or material that can be worn by the individual without affecting the daily activities or restricting mobility. Wearable technology is more importance in the fields like fitness, sports and health care. In health care, Wearable technology for monitoring the vital parameters was designed mainly to study the conditions of the post-operative patients. After surgery, continuous monitoring of the vital parameters like ECG, Heart rate and respiration rate of the individuals is required. Wearable sensors are used to measure the physiological parameters after it attached to the surface of the body. These sensors defined to be subset of devices are designed in such a way that they overcome all artifacts and environmental disturbances [14]. Wearable technology depends on batteries for their functioning. In general, the life span of the battery defines the capacity of the system or device designed. The efficiency of the wearable device for monitoring depends on the battery and wireless communication of the health conditions without restricting and affecting the user in any way [2, 11].

The wearable devices and wireless Body sensor networks developed is mainly to introduce efficient monitoring system in the field of health care. This helps the individuals in monitoring their chronic and acute events. The wearable systems designed contribute in providing postoperative rehabilitation solutions, immediate recovery and also helps the elderly to lead an independent life [6, 10]. These technologies are used to monitor the state of the patients in rural or remote cities thereby reducing the workload, comfort and reducing cost. Death rate or Mortality is reduced through the proper instructions provided by the experts to the patients . Different types of wearable devices are used for monitoring the respiratory functions of the patients. Wearable devices for respiration monitoring have been introduced to analyze the condition of the individual with respect to the environment conditions. The paper describes the working and the principles used for monitoring the respiration rate by using different types of sensors.

II. RECENT WEARABLE TECHNOLOGY FOR RESPIRATION MONITORING

Wearable technology mainly defined for monitoring parameters used to define the physiological conditions of the patient. Health care sector makes use of different advanced technologies. One among them is wearable technology for respiration monitoring. Even with the influence of the artifacts and environmental conditions, the sensors of these wearable devices analyze the physiological parameters. Different techniques used for monitoring vital parameters especially respiration parameters are described below.

In this paper the author have designed a wireless device which is capable of monitoring both ECG and respiration rate(RR). The monitoring system uses contactless capacitive based electrode which is an active electrode and an analogue conditioning circuit. The signals are transferred from device to mobile using BLE (Bluetooth technology). BLE uses low power communication with the remote server. The introduction is basically about the ECG and RR which helps in understanding the needs of the parameters to develop this wearable device. Overview of this paper defines complete hardware properties of the wearable device [3].

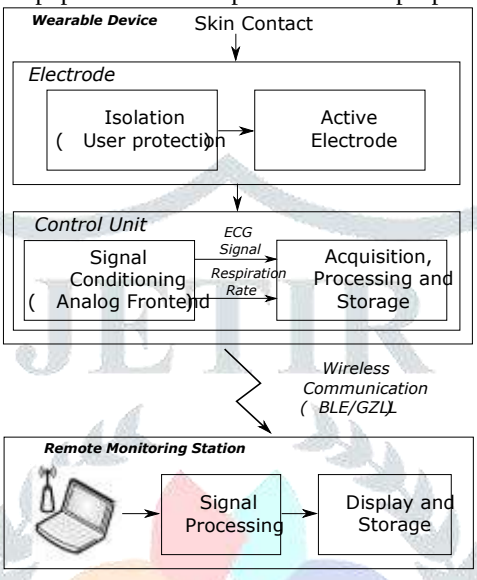

Figure 1. Design of the Wireless Capacitive based monitoring system

The device is responsible for monitoring ECG and RR by using two sub systems. They are wearable device and remote monitoring station which uses Bluetooth technology. The device is battery powered and capable of transmitting the acquisition data to the remote monitoring systems.

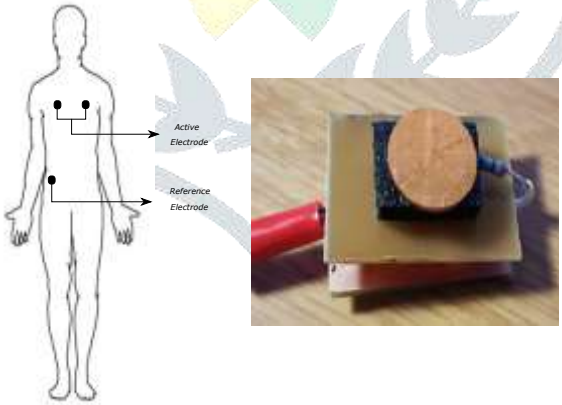

Figure 2. Structure and Positioning of the electrodes

The device set up is made in such a way that the extraction of ECG related features and RR can be monitored with a complete protection using isolation. The electrodes are place in chest using a strap which measures both the parameters through capacitively coupled signals. The signals are acquired in analogue signal and converted into digital signals using ADC. Then the signals are transferred to remote monitoring systems and observed by physician. The devices transmit both parameters to remote monitoring system but the author aims in developing this device as a promising one to monitor accurate data in future.

In this research article, a new method of obtaining the respiratory sensing for monitoring the continuous acquisition of respiratory signals based on the angular velocity. The sternum or breastbone and the trachea of is the suitable area for placing the wearable device due to its insensitivity. The respiration detection mechanism of the wearable device works under the Euler's angle formula which finds out the exact position of the fixed-point rotation from the number of parameters namely pitch angle, roll angle and the yaw angle. The experimental set-up consists of two test-beds in which the first test-bed is a inertial platform and the second

test-bed is a carbon-dioxide (CO2) concentration setup. The CO2 concentration is used to sense the accuracy of the inertial sensor platform because it is considered as gold standard reference for synchronizing the acquisition of both former and later platforms. RESPLIVE/TiniStream module from Witleaf Co.Ltd., is used in CO2 concentration platform for opening the path for signal acquisition from port to PC at sample frequency of 25Hz. The inertial sensor platform uses INVENSENSOR MPU6050 which is small, low-cost and power efficient. The sample frequency of inertial sensor platform is double than that of CO2 concentration platform (i.e. 50Hz) [4].

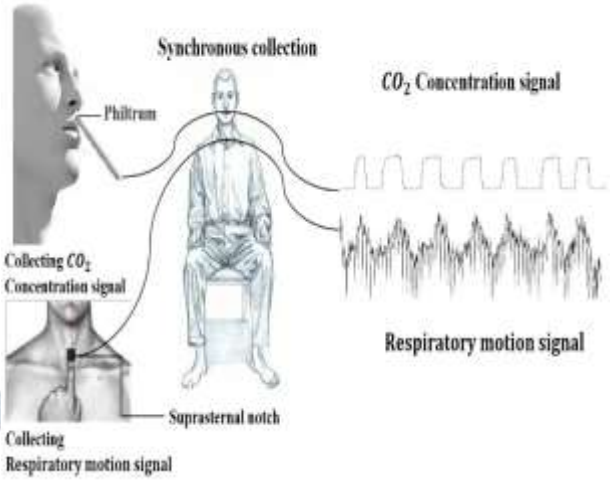

Figure 3. Recording of Respiratory motion signal

The inertial sensor in placed on the targeted area by using a double-sided tape. A nasal cannula is directly placed below the nasal cavity for detecting the air flow. The acquired data is transmitted from device to the PC. The test was done on 10 healthy subjects that include 5 males and 5 females. Single channel angular velocity module collected the respiratory signal from the targeted area in which it showed three unique frequencies. They are normal, high and low frequency. These unique frequencies analyses the respiration rate (i.e., breath at normal frequency shows 0.25Hz, at high frequency it shows 0.4Hz and at low frequency it shows 0.15Hz). The two steps algorithm is discovered in this paper. Preprocessing is done to eliminate noise and phase differences [5]. Calculation of respiration parameters like inspiration and expiration is performed in the second step. Comparing with the tradition method which uses a nasal cannula for detection the respiration signals, the proposed wearable method provides more comfort to the patient.

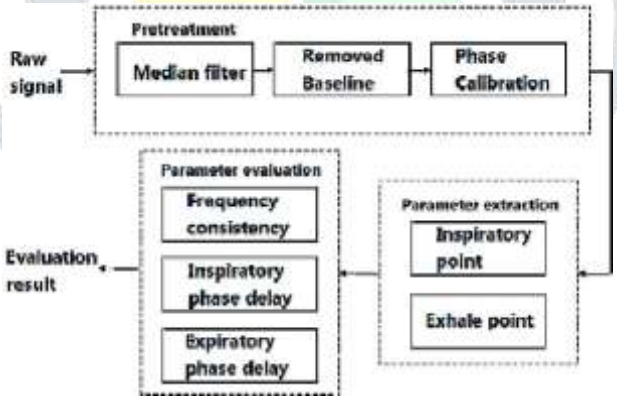

Figure 4. Design of the Wearable technology for Respiration signals

In this paper, wearable technology is designed for the monitoring of the respiratory signals continuously and also involves design of evaluation algorithm for determining signal related parameters. The proposed device makes use of Inductive plethysmographic technique and wireless body sensor networks. The fabric based inductive sensor for respiration was designed into a suit that can be worn comfortably around the neck and abdomen to monitor the respiration rate. Signal processing algorithm was designed and developed for the extraction of the varying respiration rate and parameters related to it [7].

Different wearable technologies are developed for monitoring respiration process through wireless technology. Diagnosis and monitoring of parameters seems to be more challenging in the field of health care. Internet of Things (IOT) paved a path for series monitoring of the state of the individuals. Healthcare sector makes use of IOT for transimission of information and health reports to increase the rate of survival. Few methods specially designed for monitoring respiration is discussed. Body sensor networks in wireless mode are also used for monitoring the health of the patient [8]. Rehabilitation enhancement is possible with the help of these wearable technologies which monitors the physical state of the individual by definig the vital paramters during motor activities [12]. Advancements in the field of health care involves the use of werable wireless technology for monitoring the parameters like

ECG, heart rate, respiration rate [9]. Home monitoring systems are designed with this wearable technology to provide comfort to the individuals [13]. Implantable wireless and wearable technology is available for adverse sitations were monitoring is mandatory for the healthy state of the individual. Smart technologies are used for the monitoring process in healthcare sector [15, 16]. Therefore, the described technologies are advanced innovations used to define the health conditions of the patient.

III. CONCLUSIONS

Wearable technology has come in use to a greater extent to monitor the health conditions of patients or individuals. These technologies makes use of inertial sensor, flexible capacitive pressure sensor, non-contact capacitive based electrode for monitoring the respiration rate or respiration signals and inductive respiratory plethysmography have been reviewed. The specifications and working of device changes based on the type of sensor used. The papers mentioned above describe faster acquisition of respiration signals in motion. The further approach will be done on wireless technologies which are used for monitoring respiration in motion. Wireless technology used along with the wearable technology to develop solutions for maintaining smart health care system. Special sensors are designed for monitoring the parameters and transmitting the information related to derived parameters decreases the workload of healthcare workers and increases the survival state of the patients. By proper monitoring, immediate diagnosis and treatment can be provided to the patient. Smart technology specifically wearable devices has created a smart system for monitoring the vital parameters.

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