1. CARE YOURSELF: A Self Health Care Assistant for Elderly using Visible Light Communication

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ABSTRACT

In the recent decades there is an increase in the rate of elderly population, also increased life expectancy which has brought numerous challenges to the healthcare industry. New models of self care assist devices for elderly are developed to support the demand for healthcare. The elderly care should be enhanced through various parameter monitoring system, efficient sensor system and latest communication technologies. This proposal is concerned with the assistance to the elderly. The objective of this proposal is to assist elderly to live independently and to render immediate assistance to the elderly during any illness or accidental incidents. This system aims to reduce the burden and difficulties experienced by the caregivers, decreases the healthcare costs in managing the elderly without compromising the quality of care. The proposed system employs a sensor tag to measure the physiological parameters. Visible light communication (VLC) is used in the proposed system to transmit the monitored physiological parameters from the sensor tag for further processing. The proposed device is mainly focused to detect a fall event of the elderly. If it happens, this proposed system provides an air bag inflation to prevent the person from major injury during the fall event detection. The proposed system is designed as a self-powered device.

Keywords—*Visible Light Communication (VLC), Sensor Tag, Airbag Inflation, GAIT sensor, Gyro sensor.*

INTRODUCTION

According to Word Health Organization (WHO) report, the elderly population (people aged above 60) in the world will increase drastically to 2 billion by 2050. In the year 1951 the population of elderly persons in India was 1.98 crore, in 2001 it was 7.6 crore, 10.38 crore in 2011. It is foreseen that the number of elderly (age above 60) in India will be 14.3 crore in 2021 and will increase to 17.3 crore in 2026. Modern health care technologies and government schemes on elderly has increased their survival rate.

Activities of daily living are classified into three categories such as Stationary activities, Dynamic activities and Transitional activities. Standing, sitting and lying down are called stationary activities. Transition of stationary activities to dynamic activities like sit-to-stand, stand-to-walk and sit- to-lie are called transitional activities. Running, walking, jogging and cycling are called dynamic activities. Life is made meaningful, purposeful, independent and healthier for the elderly. In today's scenario, there are so much of controversies between the older and current generation, eventually result in the isolation of elderly. Recently due to social media and internet, there is a drastic change in the lifestyle, behavior and attitude of our younger generation. There exists an opinion between the rational thinking of both the generation, so leads to the social isolation of the older people. Some people travel abroad for building their career and leaving their parents alone in their parent country. Larger community of younger generation needs privacy in their living, so they isolate their parents. Isolation of the older community may be due to so many reasons.

Being the engineer, we have to develop a device using technology which has major contribution towards the isolation of older people from the living community. The elderly might experience a feel of loneliness, insecurity, depression stress, negative impact on life which leads to various health issues like blood pressure, cardiovascular

health problems, arthritis, mobility impairment, diabetes, dementia, etc irrespective of whether they live independently or living together with their kith and kin.

The majorly developed countries have led their research in ambient assisted living. Ambient assisted living means live monitoring action and detection of human activity wellness of the elderly. A smart home with ambient monitoring allows the elderly to live independently using our latest digital devices. Significant proportion of age-related health issues for elderly are Parkinson's disease, Alzheimer's disease, cardiovascular disease and diabetes. Smart homes with ambient assisted living enhance the quality of life, provides a caretaker free environment in a secured manner. Efficient and automatic way of identifying the medical emergency situations, early disease diagnosis, routine monitoring of various disease related parameters leads to provide good care to the elderly.

Current era of medical technologies in combination with Internet of things (IoT) has emerged out with various solutions to assist the elderly community. IoT based vital monitoring systems registers and monitors the elder person's vital information and triggers an alarm during emergency conditions [1]. Smart homes based on ambient sensors [2] is designed to monitor the activities of daily living and motion of a person using passive infrared sensors, video sensors, pressure sensors in bed and chair to detect their presence, floor sensors and Radar sensors. The wearable sensors [3] designed based on the special requirements of elderly are safe adhesion of sensors without skin irritation. It is easy to apply and change. It has efficient battery capacity, good data quality, reliable data and adequate data collection platform. Advanced assistive technology [4] based elderly care has contributed community alarms, video monitoring, various types of fall detectors, health monitors, hip protectors, pressure mats, door alerts, movement detectors, dawn dusk lights, smoke alarms, fire alarms, cooker controls, electronic calendars and speaking clocks. In a smart home environment [5], vision-based fall detection is proposed by extracting the motion and shape features of body parts and the persons daily activity is differentiated from the fall using rule-based classification. An automated analysis algorithm [6] is presented to detect the high impact falls vertical velocity and acceleration features of the user from the camera, sound amplitude feature also increases the detector specificity. Rapid detection of fall events is performed using floor vibration [7], sound sensing, and signal processing and pattern recognition algorithm to discriminate the fall events from other normal activities. A smart remote monitoring of health care [8] is presented to track the user's physiological data to detect some disorders and to aid them at the earliest. An End User Development (EUD) tool [9] is developed to customize the content dependent use by non – technical users for remote monitoring and assisting elderly at home by sending the multimedia messages and reminders to change the status of various domestic appliances. Elderly or chronic illness people is supported by an Integral Assistive Home Care system [10] by installing a domotic system's core in the personal computer and an ichnographic software (SICAA) is used for patient interaction with the environment and peripheral devices. Health hazards caused by the radio frequency communication technologies have paved way for replacement of it by a VLC technology [11]. VLC employs a white light emitting diode acting as optical information emitters for efficient transmission of biomedical signals; a photodiode is used at the receiver section to receive the transmitted data. LED source offers a fast switching characteristic, longer life time and higher efficiency, so a smart phone flash light LED [12] is used as a source and an optical receiver to enable the operation of an electric lock. A microwave radiation free system [13] is designed for a longterm monitoring of a brain using a single channel wearable EEG device integrated along with VLC technology, this system is capable of transmitting upto 2.4 kbps of error-free EEG data to a distance of 4 meters.

Drawbacks of radio frequency communication include high latency, interference, requires transmission and reception setup. The above limitations [14] are overcome by VLC and provide high bandwidth and immunity to interference from electromagnetic waves. VLC is the best communication technology for the high-density wireless data coverage [15], also provides secured transmission, better bandwidth, efficient data transmission. In future laptops, smart phones and tablets will allow data transmission and reception through the lights in the room.

OPERATING PRINCIPLE

The proposed scheme makes the elderly feel safe, secured and happy, since the designed live monitoring systems keeps their relatives and their family physician updated with their physiological parameters monitored and lives independently without any assistance. The proposed device is to be fabricated in three domains such as

biomedical domain for sensor tag, communication domain to establish VLC and mechanical domain for airbag inflation.

The proposed scheme as shown in figure 1-1 employs a sensor tag comprising of various sensor like pulse sensor, temperature sensor, ECG sensor, SPO2 sensor, gait sensor, triaxial accelerometer sensor, three gyro sensors and a

piezoelectric transducer. The significance of the sensor tag is to monitor the physiological parameters to assess the health condition of the user. A multiplexer is used to multiplex the input sensor signals to provide the required serial output. Light emitting diode (LED) source is used as transmitter for transmitting the monitored parameters. The reception of data is done using a photo-detector and de-multiplexer is employed for data distribution. The received data is sent to the arduino microcontroller. In case if a fall is detected, then airbag inflation occurs, the airbag is placed around the body of the user to prevent the fall. If there is an abnormality detected in the sensor output like any changes in the physiological parameters is observed, then the message is send to the concerned doctors, close relatives and a call is initiated automatically to the ambulance to indicate the emergency situation of the patient.

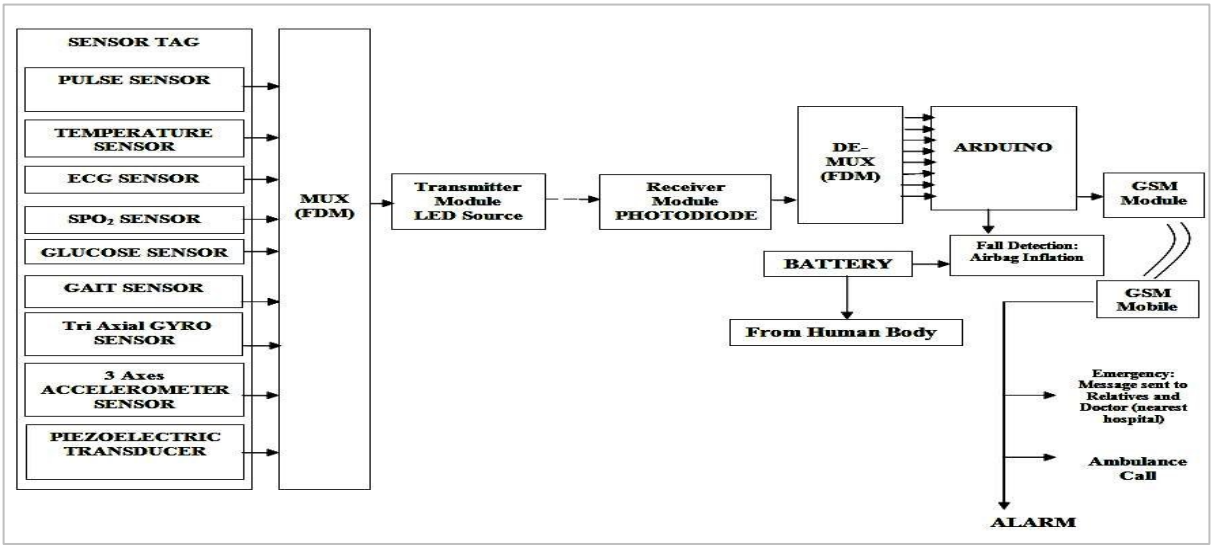

Figure 1-1 Block Diagram of proposed system

SENSOR PLACEMENT

The sensor tag is comprising of pulse sensor, temperature sensor, ECG sensor, SPO2 sensor, gait sensor, 3-axes accelerometer sensor, 3 gyro sensor and a piezoelectric transducer.

A. HEART RATE (HR) OR PULSE SENSOR:

Heart rate (HR) or pulse is the frequency of cardiac contractions, measured in terms of beats per minute. Photoplethysmography (PPG) is the conventional technique of heart rate measurement by detecting volumetric changes in the blood of peripheral circulation. A Photoplethysmography is the combination of optical and pressure sensors that obtain a plethysmogram by placing the sensors on the wrist. The working principle of PPG allows to pass a low intensity infrared (IR) light. The transmitted light is absorbed by the skin, bones, venous and arterial blood. The blood absorbs more light than the surrounding tissues. PPG detects the change in the intensity of light and produces a corresponding voltage proportional to the amount of blood flow in the blood vessel of peripheral circulation. Blood flow variations are mostly seen in arteries than in veins. A PPG signal has both AC and DC component. AC component represents the change in blood volume corresponding to each heartbeat. DC component represents the transmitted and reflected optical signals, determined by tissue structure and blood volume changes of artery and vein.

B. TEMPERATURE SENSOR

Body temperature is assessed using a thermistor configuration. The resistance of the thermistor varies based on the change in skin temperature. Skin temperature is also used to detect stress and emotions.

C. ELECTROCARDIOGRAM (ECG) SENSOR:

ECG is acquired using non-contact electrodes in a wireless system. Each heart produces an electrical pulse triggered by the cells of Sinu Atrial (SA) node, these acquired bioelectrical signals have lower amplitude. These acquired electrical signal are transformed into numerical values by ECG. The data acquisition is possible only at the chest and limbs of the user. The amplified electrical signals produce the diagnostic information of the condition of the heart.

D. PULSE OXIMETER SPO2 SENSOR:

Pulse oximeter sensor is used to measure the blood oxygenation by passing IR light and detects the reflected redlight intensities of oxygenated and deoxygenated hemoglobin. The sensor probe is placed in the patient's finger and sends to the data acquisition system and displays the calculated oxygen saturation level. LED is used as a light source, produces visible red and IR light. Deoxygenated hemoglobin allows maximum IR transmission, but red light is more absorbed. Highly oxygenated hemoglobin absorbs more IR light, but allows maximum transmission of red light to pass through it. The pulse oximeter senses the amount of light at those particular wavelengths, and produces a signal proportional to the oxygen saturation or desaturation of the hemoglobin. The pulse oximeter uses a light in the absorbency measurement, so a true light-to-voltage conversion is employed by using current as the input signal.

E. GLUCOSE SENSOR:

A wearable non- invasive epidermal glucose sensor is included to monitor the glucose level in sweat and interstitial fluid of the elderly. This sensor is a wrist watch comprising of photoplethysmographic (PPG) optical sensors. It is an indirect routine evaluation of blood components by sweat and interstitial fluids for monitoring the blood glucose levels. The measurements are done for both anteprandial and post prandial conditions. It is one of the efficient ways of measuring blood glucose concentration using optical sensor based wearable system.

F. GAIT SENSOR:

The wearable gait sensor is used to assess the gait patterns and motion of a person. The gait sensor estimates the temporal characteristics of the gait cycle i.e. stride time and the duration between the stance and swing phases. Gait cycle is defined as the time interval between the consecutive heel strikes, in other words gait cycle is the combination of stance and swing phases. Stride time is the duration of a gait cycle.

G. TRIAXIAL GYRO SENSOR AND 3-AXES ACCELEROMETER:

The combination of both accelerometer and gyro sensor provides robust fall detection. The accelerometer sensor detects the inertial changes of a body during any impact, whereas gyro sensor provides the information about the rotational velocity of the body during a fall event. During a fall event, higher acceleration and angular velocity is to be observed when compared to the normal daily activities. The wireless sensor system also employs a fall detection algorithm to recognize the abnormal fall event from the normal day-to-day activities.

H. PIEZOELECTRIC TRANSDUCER:

An inexpensive way of detecting the position of user on the floor, piezo electric transducers is used. The piezoelectric sensors are placed on the floor mat to measure the forces applied on the ground due to an abnormal fall. The force applied on the piezoelectric crystal deforms the shape of the crystal and also changes the atomic

structure of the crystal. This mechanical deformation produces a charge transfer and a voltage proportional to the applied equivalent force in the crystal.

The proposed system monitors the physiological parameters like heart rate, body temperature, Electrocardiogram (ECG), blood oxygen saturation level to assess the health condition of the elderly. Gait sensor analyses the gait patterns of the person, gyro sensors, triaxial accelerometer sensor detects the angular velocity, inertial changes and physical balance of the people. Piezoelectric transducer detects the position of the user on the floor.

VISIBLE LIGHT COMMUNICATION

The limitations of radio frequency spectrum have paved way to the rising demand for the ubiquitous connectivity and high capacity. In the year 2018, CISCO has already predicted 11 times doubled the mobile data traffic due to the increase in the number of devices using the mobile networks, also due to the development of social media. Most of the wireless devices are electromagnetic, so interference is another problem in RF wireless communication. RF communication is suffering from the following problems:

Interference, as per the Federal Aviation Administration (FAA), the mobile phone usage is restricted on aircraft due to its interference with communication and navigational systems, also causes disruption of ground towers as per the Federal Communication Commission (FCC). In a wireless communication, interference is not the only problem but also communication system requires very low latency period, so RF communication is not better due to the bandwidth limitations. RF waves have security due to their capability of penetrating walls easily. Many human health hazards are recorded due to the increased RF wave transmission power beyond the specified limit. A separate communication setup is essential for wireless RF communication due to the power inefficiency, overcome these drawbacks in RF communication systems has paved way to the newer communication technologies called VLC.

Researchers are focusing towards non-invasive monitoring of human health as well as activity parameters through the wearable devices. RF communication is in need of its own setup devices for RF wave transmission and reception. Also, RF waves may be affected by interference and latency issues. In the present scenario, VLC is a suitable communication technique as well as a complement tool for RF communication. VLC is a type of data communication. It is also a type of optical wireless communication technology. Alexander Bell coined a term called “Virtual Light Communication” (VLC) and said in the late 18th century that the future of communication will be VLC and will have higher bandwidth, higher speed with minimum interference. Much attention was paid on the year 2003 to work on VLC and currently the technology is named as “Visible Light Communication”. The wavelength of visible light is around ranging from 380 and 780nm wavelength depending on the variation of visible light color. It is a form of optical wireless communication technology for efficient data transmission at higher data rates and provides a health hazardless environment, also provides secured transmission at a very minimum cost. This proposal presents sensor output for communicating the data through visible light. VLC environment of the room will be done through white LEDs that transmit sensor output to the receiver. This proposal describes the elder care and health monitoring system, where the healthcare information such as biomedical signals from the sensor output is to be transmitted via the LED lighting. VLC data transmitters turns a light source on and off at a higher speed, so fast that even our eye cannot sense the switching rate, nor it detects any change in color or intensity. The illumination difference between the ON and OFF states of the light source correspond between the two binary values: Zero and One. The transmission standard for VLC is IEEE 802.15.7.

AIR BAG INFLATION PRINCIPLE

The air bag is to be designed as light weight and easy to wear. The airbag comprises of battery, gas cartridge and an inflatable air bag. The air bag projects the user’s head and hip during a fall event. A triaxial acceleration sensor and a triaxial gyro sensor are used to measure the movement. If a

fall event is registered, the aurdino output triggers the cartridge to cause ignition. Then, the gunpowder explodes to release the gas, making a small hole in the gas cartridge and airbag is to be inflated. The inflator is to

be made from an aluminum block big enough to avoid accidents when the gunpowder explodes. In case if a fall is detected, then airbag inflation occurs, the airbag is placed around the body of the user to prevent the fall. The entire system should be designed to have light weight, reusability, automatic and easy to use. The reusability of airbag is done using an electromagnetic valve. [16].

HUMAN POWER HARNESSING

Smart clothing is designed to have a piezoelectric crystal sandwiched between the two layers of fabric called as piezoelectric textiles. The piezoelectric textile is designed to convert the structural vibrations into an electrical energy. The user while breathing produces a strain on the piezoelectric crystal for every cycle of breathing phase. The deformation in the crystal produces a corresponding voltage, used to power the device. The gyro sensor signal output is also used to generate the power.

CHALLENGES AND FUTURE WORK

The challenge to be faced in our system implementation is ambient light interference. Many researchers have tried achieving a shortest distance between the transmitter and receiver as 120 cm in an artificially illuminated room, whereas 50 cm for naturally lit room. Indirect sunlight and fluorescent light lit room are considered as ambient light interference, the interference reduces the quality of signal reception. An amplifier is added in the transmitter circuitry and lens is added in receiver circuitry, highly efficient solar panel, noise cancellation circuit for an efficient data transmission up to few meters without any ambient light interference and also higher data transmission rates can be achieved. A part of enhancing the quality of elderly life a medicine reminder system can be incorporated to take their pills on time. In future an application may be developed for knowing the daily activities of elderly are performed on time, a self-enrollment application for the user. This application helps their relatives to assess them easily from farther place, also relatives can share their messages and photos of special moments to make the elderly stay well emotionally.

CONCLUSION

In the proposed work, a wireless wearable device is designed to enhance the quality of life of an elderly person by making them live independent. This proposed work monitors the various physiological parameters like heart rate, blood pressure, blood oxygen saturation, body temperature, ECG, body inertial changes, rotational velocity, gait patterns, fall forces in the ground during a fall event. A passive infrared sensor is to be placed in the room to detect the motion of the person. The monitored data is transmitted through VLC. Visible light communication is used in the proposed system to transmit the monitored physiological parameters from the sensor tag to the arduino board for further processing. In case of any abnormality assessed in the monitored physiological parameters as well detection of a fall event, then an emergency message send to the relatives and doctor to indicate the abnormal health condition of the person. The alarm is also set to indicate the emergency status of the person to neighbors and an automatic call is initiated to ambulance. The proposed system also has an air bag inflation to prevent the person from major injury during the fall event. The proposed work consumes the required power from the user itself. This novel work also employs a VLC based communication for data transmission and reception. The airbag inflation is another added advantage of the proposed work to prevent the fall of the elderly.

DISCLAIMER

The views expressed here are solely those of the author and do not in any way represent the views of Mercedes Benz Research & Development India or its affiliates/ group companies

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