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QUALITY-AWARE ECG MEASUREMENT AT EXTREMELY NOISY VEHICLE ENVIRONMENT AND ULTRA-FAST ALERT IN SOCIAL MEDIA

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ABSTRACT

In this paper, we propose a novel signal qualityawareIoT-enabled ECG telemetry system for continuous cardiac health monitoring applications. Vehicles are increasingly wirelessly connected and each wireless connection is a potential cyber threat surface.In the design of vehicles of public transport as much as private, it is important to know the real load properties which are put under the vehicle. Although typical load histories are available, these files were obtained in other countries where the conditions of the ways and the operation of the vehicles are very different. In order to be able to obtain histories of loads in the conditions of our country, a system based on a wireless sensing modules network has been developed to measure deformations, temperature and accelerations in multiple points of the vehicle in real time. The obtained data of each sensor is prepared, processed, stored and transmitted in time intervals towards a receiver, which is in charge to send them to a Internet server for its storage, visualization and analysis for any user connected to the network who have accessibility to the collected information and can make the pertinent procedures and actions**..**TheIoT enabled ECG telemetry system is used in a special case wherein as vehicle monitoring in a noisy environment.This paper provides a system for obtaining clear signal.The vehicle monitoring includes the driver monitoring and multipledata acquisition for continuous monitoring to avoid any uncertain situations.If any abnormalities obtained in data it is once given as an emergency alert in any of the social media such as facebook or twitter.

I.INTRODUCTION

Vehicular security is an important topic as vehicles become more connected and autonomous. Even though most vehicles on the road today are not self-driving and few have been equipped with vehicle-to-vehicle dedicated short range communications (DSRC) radios, there is already a significant amount of safety-critical systems that are controlled by onboard computers. These onboard computers have been designed in an environment where they are mostly separated from the rest of the world. Beginning with systems like OnStar and continuing now to vehicles that are sold with WiFi access points, the connectedness of these systems has significantly increased. This connectivity trend permeates many areas of critical infrastructure for which the transportation network is only one example. While vehicle manufacturers have put significant effort into securing their vehicles, their efforts are sometimes complicated by federally mandated requirements. The focus of this paper is the ECG monitoring of the driver .Internet-of Things (IoT)-driven health and wellness monitoring systems enable remote and continuous monitoring of individuals, with applications in chronic conditions such as obesity, hypertension, diabetes, hyperlipidemia, heart failure, asthma,Depression,elderly care support,preventive care and wellness.In real world applications most IOT enabled devices operate on limited power batteries for prolonged time periods.The energy consumption becomes a crucial design consideration to enhance the entire network lifetime.Literature studies showed that the battery lifetime of IoT-enabled devices is highly influenced by the power consumption of the communication network utilization for continuously sharing the sensor data to cloud server and the on-device embedded processor for event detection and modeling in real-time. Therefore, intelligent solutions are demanded to improve battery lifetime of IoT devices and to reduce diagnostic traffic load and bandwidth utilization costs. In practice, the ECG signals are corrupted by various kinds of artifacts and noise including, flat line (FL) due to the electrode disconnection, baseline wander (BW) due to the respiration, abrupt change (AC) due to the physical activities, muscle artifacts due to the muscle contraction, power line interference (PLI) and recording instrumentnoise.

II. DESIGNCONSIDERATIONS

A. Single lead heart rate monitor AD8232: The AD8232 Single Lead Heart Rate Monitor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily. The AD8232 is an integrated signal conditioning block for ECG and other bio-potential measurement applications. It is designed to extract, amplify, and filter small bio-potential signals in the presence of noisy conditions, such as those created by motion or remote electrodeplacement.

The AD8232 Heart Rate Monitor breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heart beat. Biomedical Sensor Pads and Sensor Cable are required to use the heart monitor.

B.CO Sensor :

Carbon Monoxide (CO) sensor, suitable for sensing CO concentrations in the air. The MQ-7 can detect CO-gas concentrations anywhere from 20 to 2000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to anADC.

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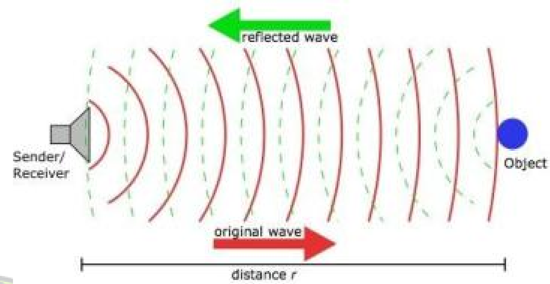
Smaller concentrations can be harmful over longer periods of time while increasing concentrations require diminishing exposure times to be harmful.CO detectors are designed to measure CO levels over time and sound an alarm before dangerous levels of CO accumulate in an environment, giving people adequate warning to safely ventilate the area or evacuate. Some system-connected detectors also alert a monitoring service that can dispatch emergency services if necessary. While CO detectors do not serve as smoke detectorsand vice versa, dual smoke/CO detectors are also sold. Smoke detectors detect the smoke generated by flaming or smoldering fires, whereas CO detectors detect and warn people about dangerous CO buildup caused, for example, by a malfunctioning fuel-burning device. In the home, some common sources of CO include open flames, space heaters, water heaters, blocked chimneys or running a car inside agarage.

C. Ultrasonic Sensor:

The sonic waves emitted by the transducer are reflected by an object and received back in the transducer. After having emitted the sound waves, the ultrasonic sensor will switch to receive mode. The time elapsed between emitting and receiving is proportional to the distance of the object from the sensor. Ultrasonic transducers are divided into three broad categories: transmitters, receivers and transceivers. Transmitters convert electricalsignals into ultrasound, receivers convert ultrasound into electrical signals, and transceivers can both transmit and receive ultrasound. In a similar way to radar and sonar, ultrasonic transducers are used in systems which evaluate targets by interpreting the reflected signals. For example, by measuring the time between sending a signal and receiving an echo the distance of an object can becalculated.

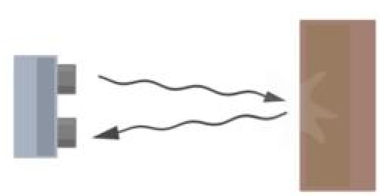
$$\text{DISTANCE} = \frac{\text{Speed of sound x Time taken}}{2}$$

Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions. Ultrasonic probes and ultrasonic paths apply ultrasonic energy to agitate particles in a wide range of materials. Ultrasound can be used for measuring wind speed and direction (anemometer), tank or channel fluid level, and speed through air or water. For measuring speed or direction, a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air or water. To measure tank or channel level, the sensor measures the distance to the surface of the fluid. Further applications includes: humidifiers,sonar,medical ultrasonography,burglar alarms,non-destructive testing and wireless charging



Reflection Mode In ultrasonic sensor

Systems typically use a transducer which generates sound waves in the ultrasonic range, above 18 kHz, by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed. The technology is limited by the shapes of surfaces and the density or consistency of the material. Foam, in particular, can distort surface level readings. This technology, as well, can detect approaching objects and track their positions. Ultrasonic transducers convert AC into ultrasound, as well as the reverse. Ultrasonics, typically refers to piezoelectric transducers or capacitive transducers. Piezoelectric crystals change size and shape when a voltage is applied; AC voltage makes them oscillate at the same frequency and produce ultrasonic sound. Capacitive transducers use electrostatic fields between a conductive diaphragm and a backing plate. The beam pattern of a transducer can be determined by the active transducer area and shape, the ultrasound wavelength, and the sound velocity of the propagation medium. The diagrams show the sound fields of an unfocused and a focusing ultrasonic transducer in water, plainly at differing energylevels.



Basic Ultrasonic Sensor Operation

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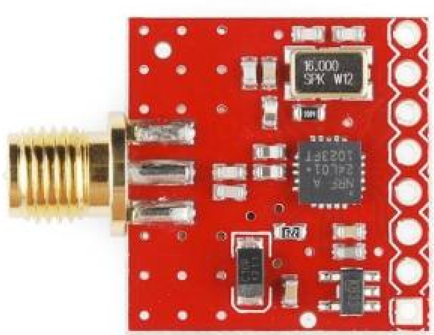
D.Accelerometersensor:

The accelerometer sensor used is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a rangeof 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.

E.nRF24L01



The nRF24L01 module is the latest in RF module, uses the 2.4GHz transceiver from Nordic Semiconductor, the nRF24L01+. This transceiver IC operates in the 2.4GHz band and has many new features! Take all the coolness of the nRF2401A and add some extra pipelines, buffers, and an auto-retransmit feature. This board features a reverse polarized SMA connector for maximum RF range. Please remember, you will need a mating RP-SMA 2.4GHz antenna (listed below).Because of lower costs and better performance, we recommend the nRF24L01 over the original nRF2401A modules. This unit has an onboard 3.3V regulator and has 5V tolerant IO lines. This makes it very flexible, but you will need to power the unit with 3.3V or higher voltage for the regulator to perform properly. The Nordic nRF24L01+ integrates a complete 2.4GHz RF transceiver, RF synthesizer, and baseband logic including the Enhanced Shock Burst™ hardware protocol accelerator supporting a high-speedSPI interface for the application controller. The low-power short-range (50-200 feet or so)Transceiver is available on a board with Arduino interface and built-in Antenna Range is very dependent on the situation and is much more with clear line of sight outdoors than indoors with effects of walls and materials. The usual distance quoted by different suppliers for the low-power version module with the single chip is 200 Feet or 100 Meters. This is for open space between units operating at a Data Rate of 250KHz. Indoors the range will be less due to walls etc... The example with radio.setPALevel(RF24_PA_LOW); will be only 10 feet or so. But reliable. There are other types of nRF24L01 modules which add Transmitter power amplifiers and Receiver preamplifiers for longer distances..up to 1 Km (3000 feet). These modules use an external antenna which can be a simple directly-attached one or a cable-connected antenna with more gain ordirectivity.

D.Engine temperature sensor: The coolant temperature sensor is used to measure the temperature of the engine coolantof an internalcombustion engine. The readings from this sensor are then fed back to the Engine control unit(ECU), which uses this data to adjust the fuel injectionand ignition timing. On some vehicles the sensor may also be used to switch on the electric cooling fan. The data may also be used to provide readings for a coolant temperature gauge on thedashboard.

III. Existing Signal QualityAssessment Methods

In remote health monitoring, signal quality assessment(SQA) is an intermediate step between ECG signal acquisition and transmission for clinical diagnosis. The SQA plays a prominent role in applications which include automated arrhythmia recognition, heart rate variability (HRV) analysis, emotional recognition, biometric authentication, and unsupervised health monitoring. In general, the SQA method grades quality of an acquired ECG signal into five groups: excellent, good, adequate, poor, and unacceptable . However, most SQA methods grade the ECG signal quality into two groups: acceptable vs. unacceptable (or good vs. bad). Various SQA methods were proposed based on energy-concavity index (ECI), correlation , power in different sub-bands of ECG components, higher-order moments and spectral energy , correlation and diversity

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approach, signal representation in spectral-domain , cross-covariance among different ECG signals , linear prediction , correlation-based kors matrix and regularity matrix , and variation of amplitudes in spectral-domain . The SQA method includes two major steps: feature extraction and signal quality ratings using heuristic rules and machine learning approaches . Most existing methods extract the PQRST morphological features, RR interval features PQRST shape regularity , proportion of R-peak amplitude and noise-amplitude , consistency of QRS wave for assessing the acceptability of ECG signals. Existing SQA methods highly demand robust methods for accurate and reliable detection and measurement of morphological and RR-interval features from noise-free and noisy ECG signals. Although the ECG morphology feature based methods have shown promising results in noise-free ECG recordings, accuracy and robustness of QRS complex detection and waveform delineation methods are significantly degraded in the presence of severe muscle artifacts and other external noise. Machine learning SQA methods demand a large collection of different patterns of ECG signals and various types of ECG sources for accurate modeling of signal and noise patterns. However, existing SQA methods may demand more computationalpower.

B. Objectives and Contributions

Signal quality-aware paradigm is a promising technological solution for the IoT that has great potential to significantly improve the resource utilization efficiency (including, battery power consumption, network utilization, bandwidth and treatment costs, cloud server traffic load) and to improve the accuracy and reliability of unsupervised cardiac health monitoring and diagnostic systems in wearable medical body area network environments. With signal quality-aware IoT paradigm, signal processing/event detection and communication modes can be put to sleep when unexpected level of background noise and artifacts are detected from ECG signals that can significantly alter the morphological features of the ECG signal. Processing and analyzing severity of ECG noise sources can play a significant role in improvement of resource utilization efficiency by reducing high number of computation and communication actions on severely corrupted ECG signals which exhibit significant variations in morphological features of the local waves.In this paper, we propose a novel signal quality-aware ECG telemetry system for IoT-enabled cardiac health monitoring in wearable medical body area networks. The main objective of this paper is to present a light-weight real-time signal quality assessment technique for improving battery lifetime of IoT-enabled wearable devices and reducing the cloud server traffic load, bandwidth and treatment costs.

IV. PROPOSED SIGNAL QUALITY-AWAREIOT-ENABLED ECG TELEMETRY FRAMEWORK

The main modules of our signal quality-aware (SQA)-IoT framework consists of three modules: (i) ECG signal sensing module, (ii) automated signal quality assessment module, and (iii) signal-quality aware ECG analysis and transmission module. In this paper, we mainly focus on design and real-time implementation of automated ECG signal quality assessment method and validation of the effectiveness of the proposed SQA-IoT framework under resting, ambulatory and physical activity conditions. The proposed automated ECG signal quality assessment (ECG-SQA) method consists of three steps such as flat-line (or ECG signal absence) detection, abrupt baseline wander extraction, and high-frequency noise detection and extraction to compute the signal quality index (SQI) for assessing the clinical acceptability of ECG signals. In this work, the ECGSQA is implemented based on the discrete Fourier transform (DFT)-based filtering, turning points and decisionrules.

A. Baseline Wander Removal and Abrupt ChangeDetection

In practice, the ECG signals are corrupted by baseline wanders that are mainly caused by respiratory activity, body movements, skin-electrode interface, varying impedance between electrodes and skin due to poor electrode contact and perspiration . Under physical activities, the baseline wanders can degrade the ECG signal quality and may severely affect the PQRST complexes. The presence of baseline wanders with abrupt changes makes determination of characteristic points of local waves of ECG beats more difficult. The frequency of the baseline wander lies below 0.8 Hz (upto 1 Hz during stress).In this work, we perform baseline wander detection using the discrete Fourier transform (DFT) based filtering approach.

B. ECG Signal AbsenceDetection

Due to the disconnection of electrodes with skin and the electronic component saturation, sensing device exhibits the absence of ECG signal information in the

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acquired signal. In practice, we observe that the recording shows the presence of zero amplitude flat line (ZFL), only baseline wander (OBW), and the long pause with physiological and external noises. Existing approaches were developed for detection of ZFL event. In this work, we present a novel approach for detecting a fore mentioned noise events.

C. HF NoiseDetection

In practice, the high frequency (HF) noises such as muscle artifacts, powerline interference, motion artifacts, pause and instrument noise are introduced in the acquired ECG signal. These HF noises can obscure the local waves (P, T, U and small amplitude QRS complex) of the ECG signal. Thus, it is difficult to perform more accurate and reliable measurement of morphological parameters such as amplitude, duration, pause interval, timings, polarity, and shapes of the local waves. Removal of HF noises especially, muscle noise is quite challenging without distorting the local waves of thesignal.

D. ECG Signal QualityGrading

In this work, we perform the grading of acquired ECGsignal based on the decision scores obtained for the detection of abrupt baseline wander, ECG signal absence, and high frequency noises. The ECG signal is graded with three classes such as Good, Intermediate and Bad based on the HF noise score. The presence of flat line and abrupt baseline wander may result in noisy clinical features. Based upon assessment results, it is noted that the some morphological features and RR intervals can be measured from the ECG signal with some level of HF noises. Thus, we grade the noisy ECG signal into intermediate and bad. The value of H is chosen as 0.1% of the maxima or minima in the HF noise detection stage for detecting severe noise or bad quality signal. While the noise level threshold H is set to 0.05% of the maxima or minima for grading the noisy signal into intermediateclass.

E.Data Acquisition modes

In data acquisition mode ARM-7 microcontroller acquires and stores different parameter of the vehicle. The main block of Wireless Data Acquisition System to microcontroller. The temperature of the vehicle is sensed by the temperature sensor and this is measured for Vehicles is ARM-7 micro controller which is heart of the system which provides monitoring and controlling actions. It senses signals from input blocks and processes output blocks. The software program is stored in ARM-7 microcontroller on chip memory, according to which it provides the controlling actions. The on chip ADC converts these parameters into digital form and gives to the ARM-7 microcontroller. The status of driver health conditions i.e. whether the ECG signal is normal or unconditional is sensed by the block and gives the corresponding signal in RPM by ARM-7 microcontroller. With the help of keyboard block the driver can enter the password along with cabin temperature. The LCD block is provided for visual display of the message and password. Also it continuously displays the measured parameters. The RTC provides real time clock depending on which the various eventsoccur.

V.IMPLEMENTATION

NRF module can able to send data within the distance from 100 meters to 2 kms. By using NRF module, we implemented a system which receives signals from vehicles and it transmits to base station. NRF is connected with the micro controller using I2C communication. Three axis accelerometer is used to detect the tilt angle of vehicle, this is also communicates through I2C with micro controller. MQ7 sensor is used to detect carbon monoxide emission from the vehicle. Ultrasonic sensor is used to detect obstacles in the road. AD8232 monitors the driver's ECG signal and it gives updates to the controller.The micro controller is connected with the raspberry pi through NRF, which updates the driver and vehicle details to social network.

The data can be programmed using the python language script and t s updated into the internet as an emergency alert.

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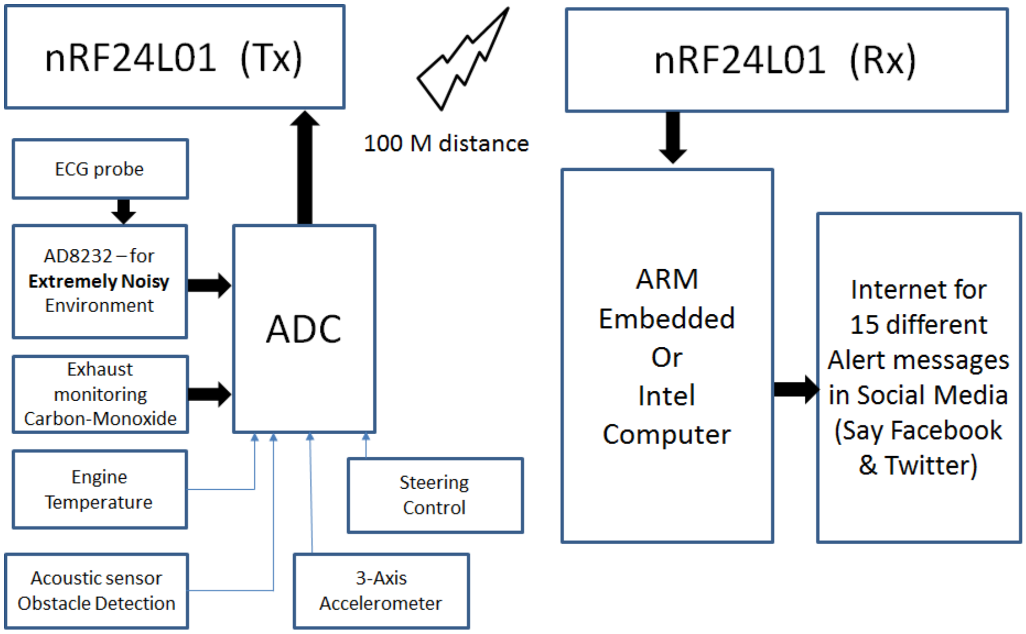
VI.BLOCKDIAGRAM



The system consists of AD8232 for ECG signal monitoring and vehicle data acquisition. The vehicle data acquisition consists of exhaust monitoring, engine temperature sensor, acoustic sensor, three axes accelerometer, flame detector with water sprinkling system. The ECG probe is connected between the driver and the AD8232 ECG sensor which obtains a clear signal incase of extremely noisy environment. It has a digital output which is given to analog to digital convertor. CO sensor monitors the exhaust of the vehicle.When CO emission is increased the sensor indicates a signal for abnormal situation to avoid the air pollution. Engine temperature sensor is used to avoid the increase in temperature and it can be controlled. Acoustic sensor is used for obstacle detection ,it avoids accidents and also avoids rollover situation for a long vehicle. Three axes accelerometer is a tilting sensor.When the vehicle is driven faster at the curves this sensor indicates tilting angle.Flame detector with water sprinkling system ,it detects the flame and once it senses the flame a motor is setup to sprinkle the water automatically.The outputs of these sensors are in analog form. The outputs are collectively given at the input side of an analog to digital convertor. The analog signals are converted into digital form and then it is transmitted through the nrf transmitter at the transmitting side. At the receiving side nrf receives the signal and sends them to ARM embedded. The nrf can transmit the signal over 100m distance.These outputs can be categorized into critical and normal situations. It is programmed using python script and given as the alert in the facebook or twitter in case of emergency situations.

VII.CONCLUSION

Hence we conclude that this project not only useful for acquiring data but we can analysis and also control the parameter. Thus it is helpful to avoid accident, gas leakage, very high temp etc .Thus it becomes very easy to acquire and analyze the data of moving vehicles. With help of this project we can get data anywhere in the world. In this paper, we present a novel signal quality-aware IoT enabled ECG telemetry system for cardiac health monitoring applications. Real-time evaluation results further show that the proposed quality-aware ECG telemetry system significantly reduces the battery power consumption by transmitting the acceptable quality of ECG signals and putting the IoT devices to sleep mode for the unacceptable ECG signals. From experiment results, our proposed algorithm will be able to detect driver warning situation. Further, it will be able to utilize for the purpose of determining the cause of the traffic accident.The abnormalities in the ECG signal is given as a post or alert in facebook or twitter under two conditions critical and normal.So that any emergency situation can resolved at once without anydelay.

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