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COMPRESSED SENSING OF ECG SIGNAL FOR WIRELESS SYSTEM

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Abstract - *Compressed Sensing, is the new compression techniques, mainly contain three main requirements: incoherence measurement, nonlinear reconstruction and sparsity representation. Which refer to the signals, the encoding and the decoding techniques? The main goal of the Compressed Sensing is to reconstruct the sparse signal using a small number of linear measurements of signal accurately. In wireless sensor networks battery back-up is used for transmission of data due to this the energy loss occurs during transmission of data. In intra-hospital automated data collection system are used for acquisition of the different ECG wirelessly by nurses and doctors, they used the acquisition node for collect the data. The data or signal are now send to a single center for further processing and by this they offer easiness of management of ECG equipment's as communications process has no wires. They send the acquired ECG signal wirelessly to nearest point. ECG signals has cyclic pattern in nature .so, they compressed and transmitted the signals at the transmitter node and they can save energy of the battery support of transmitters, there is necessitate to discover compressed sensing method for ECG signals. In this work we have evaluate, the existed methods and algorithm of compressed sensing technique for ECG signals. Our goal is to give the further enhancements in the existed system used for compressing. Our objective is taken alternative of existing algorithms such as Basis pursuit. This can be applied at the place of LS-OMP to get better performance and to consume less energy and time. In our work we evaluate the different parameter like RSNR,PRD,TIME of our algorithm and the existing algorithm to show the performance of our algorithm used for compressed sensing of ECG signal*

Key Words: **Wireless sensor Networks, compressed sensing, Health monitoring, ECG signals, DWT AND IDCT**

1. INTRODUCTION Now these days, the application of Wireless Body Area Network for patient monitoring has grown significantly today. These technologies could greatly benefit patient monitoring systems in hospitals, residential and work environments and also has low cost using wireless sensor network. These WBN based system use for easy internetworking with other devices and offering health care to patient's critical as well as non-critical data. AWBAN based monitoring system also used for athlete's to assist them in their training activities.. A WBAN has two nodes that are incorporate wearable and implantable nodes operating in two different frequencies. An implantable node is most likely to operate at 400 MHz used the MICS (Medical Implantable Communication Service) band and the wearable node operates in ISM or UWB (Instrumentation Scientific Medical/Ultra Wide Band) bands or in some other specific bands. In a patient monitoring system, data transmission reliability and latency is extremely important for patient regular and accurate monitoring. The parameter of a WBAN depend on the design of physical (PHY) and medium access control (MAC) layers. For an optimum network efficiency and reliability the MAC layer needs to be designed to meet specific needs of specialized WBAN applications. An IEEE802.15.6 standard group is used in the development of body area network architecture. The new standard will

define the PHY and MAC layer management issues which could be used to develop a

- low cost,
- ultra low power and
- highly reliable wireless network

WBAN system can produce two significant advantages: first is mobility of patients by using portable monitoring devices; second is the facility of location independent monitoring

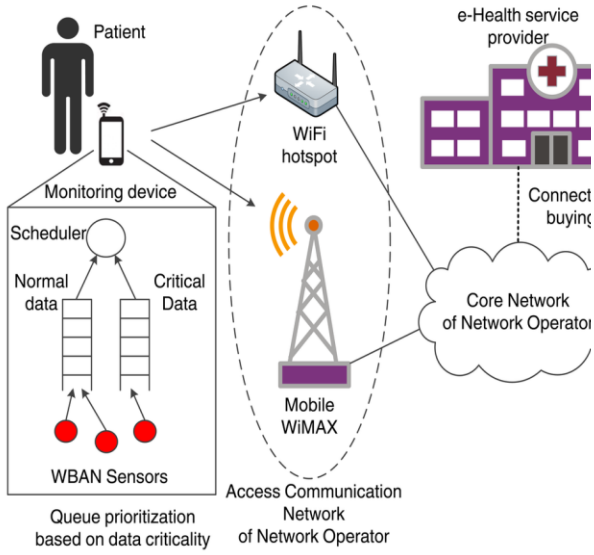


Fig -1: WBAN NETWORK USED FOR HEALTH MONITORING

2. Compressed sensing

In the previous imaging systems the signals are uniformly sampled at high rate and then most of the sampling data are not used because to do compression. Then why we take the little part of the signal and don't used the most of the samples. A new sampling method known as compressed sensing (CS) is used to reduce the wastage of the most of the samples. CS is a new technique followed by compression, transmission or storage. CS acquiring and compressing the signals at the same time. In the CS if the signals are sparse, then they will be recovered from a small number of random linear samples. CS is the having possibility to reduce the sampling rate significantly in many signal processing applications like cameras, medical scanners, fast analog to digital converter, high-speed radar.

Compressive sensing mainly contains three steps:

- sparse representation of the signal,
- Measurement matrix
- Reconstruction algorithm.

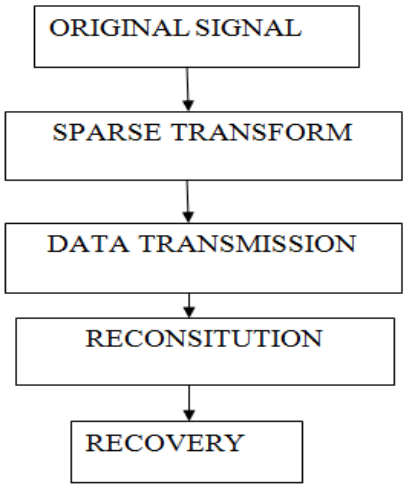


Fig -2: FRAMEWORK OF COMPRESSED SENSING

In compressive sensing, the signal is transformed using Fourier transform (FT), wavelet transform (WT), discrete cosine transom (DCT)) into sparse domain, then the measurement matrix related to transform basis can be designed to measure the signal, and the measures values can give the exact or approximate signal reconstruction by solving numerical optimization techniques. However, there are many constraints that need to know during the designing such a system these are

- Due to limitation on battery life, it is necessary to reduce energy consumption as much as possible. Low-energy consumption means that a system can use small and light batteries and sensors.

- The light weight of the device can significantly improve the comfort level of patients. It also reduces operational costs of the system.
- The transmitted physiological signals should be largely compressed. This is because the communication capacity of ultralow-power short-haul radio devices is low and can be stressed high-speed sampling frequency
- WBAN based systems normally used the Smartphone's for intermediate point. Therefore it is important that data stream doesn't conflict with normal functions of phone like receiving and making phone calls.
- Another constraint is hardware costs. Low hardware costs are mostly making the system more accepted and easily available. Low hardware costs can be obtained by getting data compression should have low complexity, and that data recovery (in remote terminals) should not require sensors to preprocess raw signals when collecting them.

Many conventional data compression like wavelet compression cannot satisfy all the above problems simultaneously. As compared to wavelet compression, compressed sensing (CS) using sparse binary matrices as its sensing matrices, can reduce energy consumption while achieving competitive data compression ratio. CS algorithms can only work well for sparse

2.1 APPLICATION OF COMPRESSED SENSING

Compressed sensing is rapidly growing field which has attracted considerable attention in

- electrical engineering
- applied mathematics
- statistics
- Computer science

Medical Applications of CS

In this work we are mostly review the use of compressed sensing in the medical application In medical field, bio-signals such as ECG signals are sparse in either Fourier or wavelet domain which makes them good candidate for CS.

3. PURPOSED METHOD

The proposed coding and decoding process is based on the theory of compressive sensing, try to make the signal compression a good way to make us able to reconstruct it after transmitting it using WBAN system. The process starts with reading the ECG signal which has length N, we divide it into many segments, each segment has a *length n*, and the segmentation operation has a significant effect on the operation of compression and reducing the computation process. If X denotes an ECG signal, then xi denote data of each segment having length n. We design a measurements matrix ø (random Gaussian matrix or binary matrix) where ø is $M \times n$ where M and n represent No. of measurements need and the segment length segment respectively. In order to get best reconstructed for K-sparse signal for original signal, ˚ needs to obey the RIP condition Since transmitting signal here work for WBAN system, it is better to use binary measurement matrix because its simplicity in transmitting and also give better compression as it compeer with Gaussian matrix. The segmentation process has two advantages:

- It makes the operation of coding fast and reduce the computation operations,
- It deals with the same measurement matrix ˚ for all the segments that we have. Usage of single matrix gives a great benefit since we work on WBAN system, the need of compression is so important to transmit the signal through radio frequency.

After that, each segment xi does the operation of transformation to some knowing base to make the signal

sparse˜(xi). Many transformations are used like Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT). In our proposed method a DWT has been used. The final operation is re-assembling the measurement vectors *yi* into one vector *Y*. The size of *Y* will be equal to (*N***M*) ×1(i.e. if *M* = 1000 and there are 3 segments, size of *Y* will be equal to (1200 × 1). In decoding part, a reconstruction algorithm for the original signal is start depend on receiving signal

Y= *Y* + noise, and ˚. The first step begins by segmentation of *Y*' into many segments, each segment has length = *M*. For recovering of the ECG signal our new proposed algorithms – Basis pursuit orL1 minimization is used to recover the signal *X*. In fig-3: block diagram of purposed work is shown.

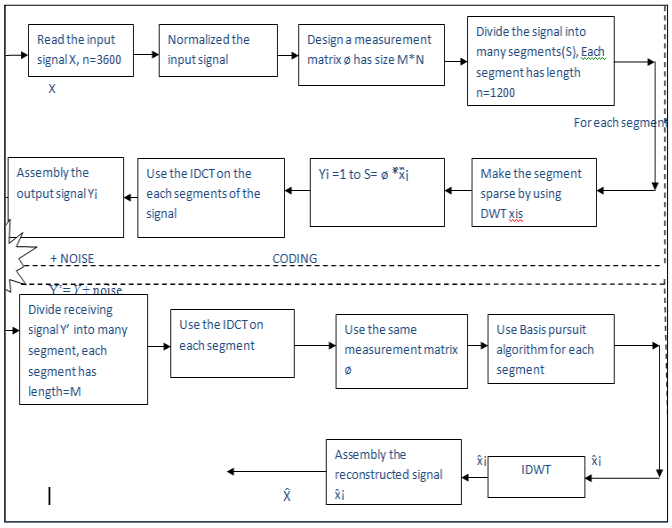


Fig -3: BLOCK DIAGRAM OF THE PURPOSED WORK

4. EXPERIMENTAL RESULTS

In our procedure we compressed the signal and decompressed the ECG signal. So, we take the test signal from the PhysioBankATM From the database of 168 short ECGrecordings(20.48secondseach)
https://www.physionet.org/physiobank/database/cdb/

We use the signal for record 08730-01, the signal length Is N= 3600 the segment length is n=1200, no of the segments =3, measuring matrix has size 1000*1200, db4 DWT is used the transmission was effected by WGN=10db, 20db.We use Basis pursuit method in our work and compare its result with the method LS-OMP used in the base paper for compression and decompression. In fig 4 shows the recovering of the signal from the noisy signal here M=1000,n=1200 The total length of the signal N= 3600 which is segmented into the 3 segments each segment has length 1200.during the compression out of the 1200 bits we send the data on 1000 bits for compressing purpose. a) The original signal is shown here and b) the noise will get added during the transmission in each segment as shown in this fig. and c) the recovered signal that we get after compression and decompression. At the M=1000, we get the max R-SNR .i.e38.2897.this signal is corrupted with Gaussian noise WGN=10db

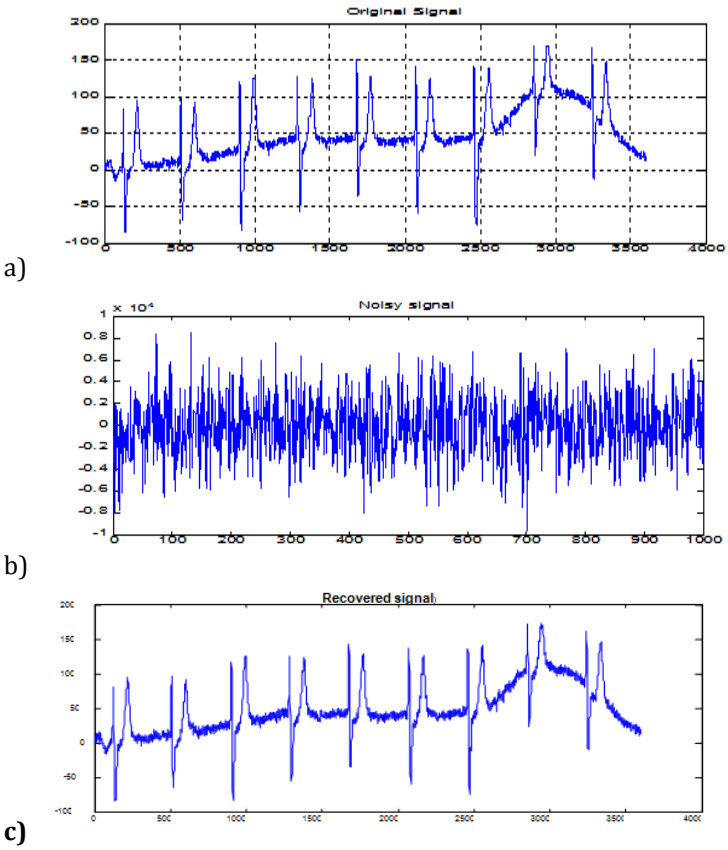
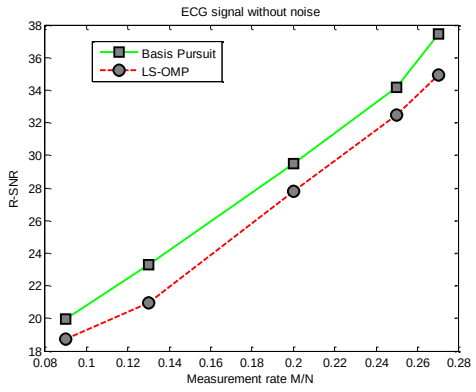


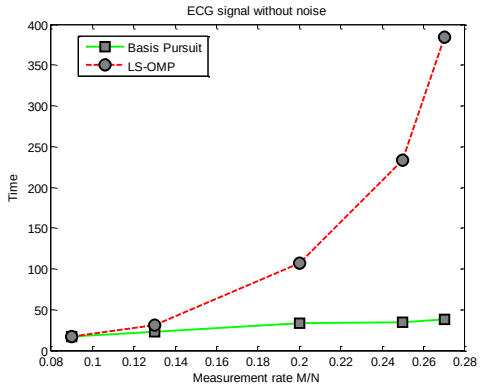
Fig -4: a) shows the original ECG signal b) shows the noisy signal c) shows the recovering signal from noisy signal

4.1 ECG signal recovery without noise

In this we doesn't use any type of noise .this is the result of the previous and purposed work without noise



a)

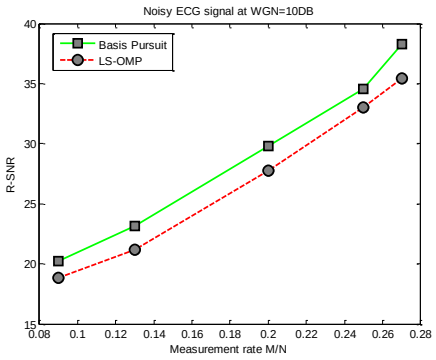


b)

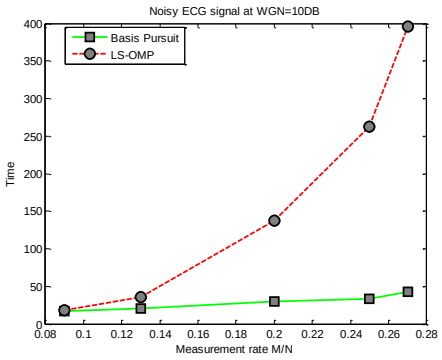
Fig -5: comparison of LS-OMP AND BASIS PURSUIT without any noise a) R-SNR vs. Measurement rate b) time consume vs. measurement rate

WGN=10db

This is the result of the purposed work and the previous work .purposed work uses Basis pursuit algorithm during compression .and previous work uses LS-OMP algorithms for compression and decompression of the ECG signal .their results are shown there where we take the Gaussian noise =10db.the result is in the form of R-SNR(reconstruction signal to noise ratio),time consume. In Fig-6: a) shows the R-SNR values and b) shows the time consumes by both the algorithms. As shown the RSNR RATIO of our work is much better than previous work and also our work will consume less time .R-SNR vs. Measurement rate, Time vs. Measurement rate is shown IN this N=3600,M value are 350,500,750,900,1000 .at M=1000 it will give better results



a)



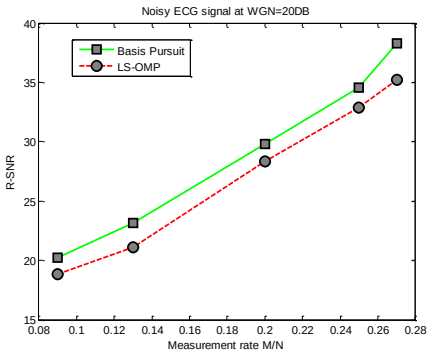
b)

Fig -6: comparison of LS-OMP AND BASIS PURSUIT with WGN noise at 10db a) R-SNR vs. Measurement rate b) time consume vs. measurement rate

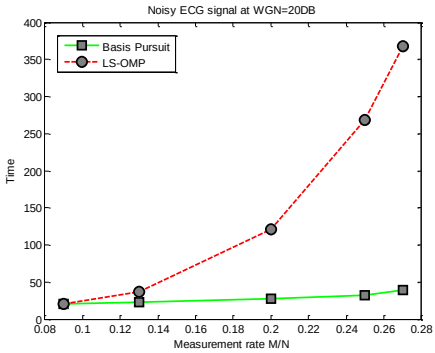
WGN=20DB

This is the result of the purposed work and the previous work .purposed work uses Basis pursuit algorithm during compression .and previous work uses LS-OMP algorithms for compression and decompression of the ECG signal .their results are shown there where we take the Gaussian

noise =20db.the result is in the form of R-SNR(reconstruction signal to noise ratio),time consume. In Fig 7 a) shows the R-SNR values and b) shows the time consumes by both the algorithms. As shown the RSNR RATIO of our work is much better than previous work and also our work will consume less time .R-SNR vs. Measurement rate, Time vs. Measurement rate is shown IN this N=3600,M value are 350,500,750,900,1000 .at M=1000 it will give better results



a)



b)

Fig -7 comparison of LS-OMP AND BASIS PURSUIT with WGN noise at 20db a)R-SNR vs. Measurement rate b) time consume vs. measurement rate

Fig 8 shows the comparison of the LS-OMP AND BASIS PURSUIT in the term of PRD (percentage root mean square difference).The ECG signal uses the PRD .Especially since ECG signal uses wavelet transform in most of the CS algorithms. The ECG signal was infected with WGN=10db.compression rate increases the PRD also increases. Again the new purposed algorithm show the best evaluation results

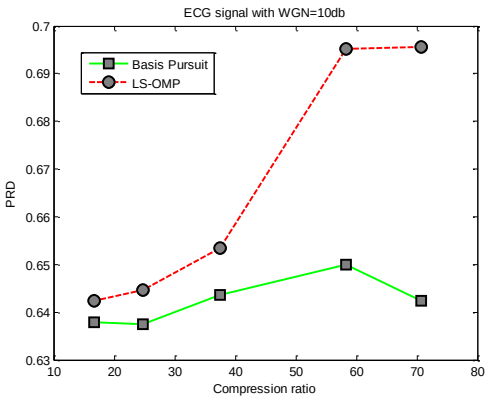


Fig -8: comparison of LS-OMP AND BASIS PURSUIT with noise WGN=10db for PRD and compression ratio

TABLE-1: TABLE TO SHOW THE RESULT OF PURPOSED ALGORITHMS WITH NOISE AND WITHOUT NOISE

MEASURMENT RATE	BASIS PURSUIT (PROPOSED WORK)				RESULT WITHOUT NOISE	
N=3600	WGN=10DB		WGN=20DB		BASIS PURSUIT	
M/N	R-SNR	Time (sec)	RSNR	Time (sec)	R-SNR	TIME (sec)
0.09	20.1985	17	20.1977	20	19.9806	17
0.13	23.1753	20	23.1680	23	23.2715	23
0.20	29.8169	30	29.8203	27	29.4977	33
0.25	34.5403	33	34.5427	32	34.1550	34
0.27	38.2897	43	38.3075	39	37.4181	38

TABLE-2: TABLES TO SHOW THE RESULT OF PURPOSED ALGORITHMS WITH NOISE WGN=10db, IN FORM OF PRD AND COMPRESSION RATIO

COMPRESSION RATIO	PRD(BASIS PURSUIT)PURPOSED
70.8	0.6423
58.3	0.6500
37.5	0.6437
24.82	0.6374
16.67	0.6378

CONCLUSION

In previous works, a new fast greedy pursuit algorithm named Least Support Orthogonal Matching Pursuit (LS-OMP) and Least Support De-noising OMP (LSD-OMP) has been used, that Methods uses discrete wavelet transform for this purposes in which noisy signal is also considered for reconstruction. In our work we first implemented the provided algorithms and then explore the comparison of results using different algorithm named Basis pursuit in form of different parameters like R-SNR, TIME, PRD etc .our purposed algorithm gives the best performance than previous algorithm as it gives RSNR=38.2897,in the time interval of 43 sec which is the much good result than the previous work. This conclusion has been drawn from the study of the test results RSNR, PRD, TIME; CR etc have shown the best performance of purposed algorithm Basis pursuit compared to LS-OMP.

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