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Application of Fuzzy Inference System for Video Compression

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A B S T R A C T

Video compression efficiency and the compression quality are determined by the motion estimation algorithm, it is a compulsion to develop a fast motion estimation algorithm with low computational complexity as the efficiency of motion estimation algorithm is directly related to compression ratio , image quality of decoded video and coding speed .In this research paper a fuzzy inference system is introduced for the calculation of motion estimation. The individual frames are divided into blocks and the fuzzy membership function value is calculated for every macro block in the previous frame and current frame with the fuzzy inference system a minimum block distortion is selected and motion vectors are computed for the predicted frame.

Keywords - Motion Estimation, Fuzzy Logic, Compression, Current Frame, Reference Frame.

I. INTRODUCTION

Full search is the simplest algorithm which find the block in the reference frame with minimum sum of absolute difference here comparison is done with all of the blocks in the search area which increases the computational complexity [1]. To avoid the computational complexity of full search algorithm many several algorithm have been introduced which assumes the error is occurred in a single mode but within the frames the pixel redundancy may differ as it depends on the movement in the video. So if a fuzzy technique is applied the uncertainty in pixel redundancy can be minimized . Spatio-temporal fuzzy search algorithm where a look up table is used can be considered[2].

II. RELATED WORK

Suvojit Acharjee et al. [3] suggested an algorithm named, "Fuzzy Logic Based Three Step Search Algorithm for Motion Vector Estimation". In this a fuzzy logic based three Step Search algorithm has been implemented . This provides the better results than the Three Step Search(TSS), New Three Step Search(NTSS), and Four Step Search(FSS) algorithm[3].

Suvojit Acharjee et al. Sheli Sinha Chaudhuri [4] suggested a Fuzzy Logic Based Four Step Search Algorithm for Motion Vector Estimation. In the fuzzy logic based Four Step Search algorithm a fuzzy membership value introduced according to intensity for every block. From the intensity values of the pixels within a macro block a value is calculated which defines whether the macro block is in darker or lighter region. Search can only work if the fuzzy membership value of the macro block of the reference frame is in the permitted range of macro block of the coordinate system is within the allowable range of macro block of the present frame. The search pattern and other step is similar like four step search[4].

Hung-Ming Chen et al. [5] suggested Fuzzy Thresholding Early Termination Scheme of Fast Motion Estimation . The proposed algorithm is an early termination scheme which depends on threshold values obtained through fuzzy inference. The search patterns of MDGDS algorithm are used. The alternative

search patterns of fuzzy inference on applied three times using an scale factor. In each round of the search the search can be terminated early prior to the each round to prevent unnecessary computation. It reduced the number of search point when it is compared to MDGDS. The algorithm makes significant improvements in motion estimation[5].

Mohammed Alreshoodi,et al.[6] suggested Fuzzy logic inference system-based hybrid quality prediction model for wireless 4k UHD , H.265 coded video streaming. In real time video streaming to maintain the quality of service is not practical .The available tools are not sufficient to provide the original video streaming at the receiver end. A survey on the impact of quality of service (QoS) parameters for the 4kUHD in H.265-coded video transmission in under experimental environment. The model based on fuzzy logic inference system is developed to predict the visual quality by mapping QoS parameters to the measured quality of experience[6].

Davoud Fani,et al. [7] suggested GOP-level fuzzy rate control algorithm for high-delay applications of HEVC. Video broadcasting and video streaming applications where the high-delay video is noticed if a variable bit-rate videos is applied a higher video quality can be rather than constant bit rate videos. The suggested this algorithm , a rate control algorithm (RCA) can be implemented for HEVC standard with a buffering constraint. In the RCA algorithm a fuzzy controller and a virtual buffer are used. The role of fuzzy controller minimizes the fluctuations of quantization parameter when the buffering constraint is applied . For each group of pictures it computes a base quantization parameter . By this way unnecessary fluctuation of quantization parameter is removed thus a higher visual quality can be achieved

Linh Van Ma,et al. [8] suggested Fuzzy-Based Adaptive Streaming Algorithm for Reducing Entropy Rate of DASH Bitrate Fluctuation to Improve Mobile Quality of Service. DASH is technology which deals with uncertainty of network . The quality of a video streaming fluctuates along with the network changes, and it might reduce the quality of service. Streaming over HTTP (DASH). Moving average of the bandwidth and buffer values for a given period, are first calculated. On the basis of differences between real and average values, a fuzzy logic system is used to deduce the value of the video quality representation for the next request.

Hyun Jun Kim,et al. [9] suggested Modification of the Fuzzy Logic Based DASH Adaptation Scheme . The suggested proposed scheme (mFDASH) modifies the Fuzzy Logic controller by using a appropriate bit rate controller thus estimates more accurate bandwidth which is better than FDASH.

Bachu Srinivas and K Manjunathachari [10] suggested Adaptive Order Cross–Square–Hexagonal search and fuzzy tangential-weighted trade-off for H.264 in motion estimation. The algorithm, which employs a smaller cross-shaped pattern before the first step of a square pattern and replaces the square-shaped pattern with the hexagon search patterns in subsequent steps. To find the best matching block is considered not increasing the search point rather than A fuzzy tangent –weighted function is applied to calculate the rate of distortion to select the matching points

Bachu Srinivas and N. Ramya Teja [11] also suggested Fuzzy Holoentropy-Based Adaptive Inter-Prediction Mode Selection for H.264 Video Coding. As put forth by the authors, the major drawback in the H.264 is that it performs the exhaustive search over the interlayer prediction to gain the best rate-distortion performance. To reduce the computation overhead due to exhaustive search on mode prediction process, a new technique for inter prediction mode selection based on the fuzzy holoentropy has been presented.

III. PROPOSED FRAMEWORK FOR MOTION ESTIMATION

The individual frames are divided into blocks and the fuzzy membership function value is calculated for every macro block in the previous frame and current frame with the fuzzy inference system a minimum block distortion is selected and motion vectors are computed for the predicted frame

The basic block diagram of the proposed frame work for the motion estimation depicted in figure1 .

Step: 1 The video frames are divided into blocks .

Step: 2 Fuzzy membership function of every macro block is evaluated in the previous frame

Step: 3 Fuzzy membership function of every macro block is evaluated in the current frame

Step: 4 Set the search window parameter

Step :5 By applying fuzzy logic search direction is decided

Step :6 Fuzzy inference system generates the inference according the input given .

Step :7 The minimum block distortion is considered as a best block

Step :8 Compute the motion vectors of the predicted frame.

Step :9 Motion estimated frame is predicted.

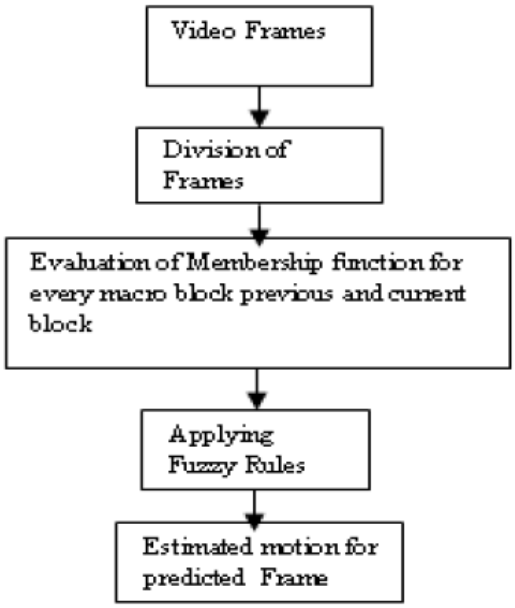

Figure 1: Proposed Basic block diagram

IV. EXPERIMENTAL RESULT AND DISCUSSION

For the implementation of proposed algorithm a video clip named "foreman.avi" has been taken the bit rate of this video is 4 bits/s ,the frames are the size 352x288. The proposed algorithm uses search area p =8 pixels and the block size =8 pixels , p=8 , b =16 and p=16 and b =16. Figure 2 ,3 and 4 shows the comparative results with other algorithms as Full search , 3 step search and proposed method . The PSNR

comparison reflects in table 1 . All the results have taken from MATLAB software for the implemented algorithm.

(A)Taking the search area p=8, b=8

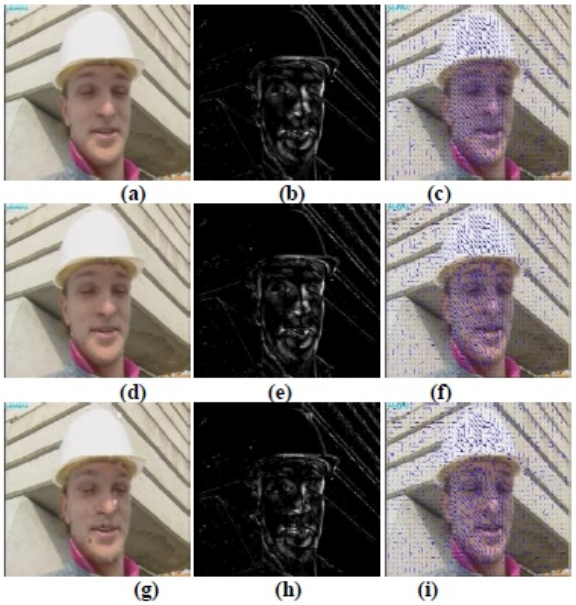

Figure 2: (a)Predicted Frame(FS) (b)Residual(FS) (c) Motion Vector(FS) (d)Predicted Frame(3SS) (e)Residual(3SS) (f) Motion Vector(3SS) (g) Predicted Frame(Proposed) (h)Residual(Proposed) (i) Motion Vector(Proposed

(B)Taking Search Area, p=8, b=16

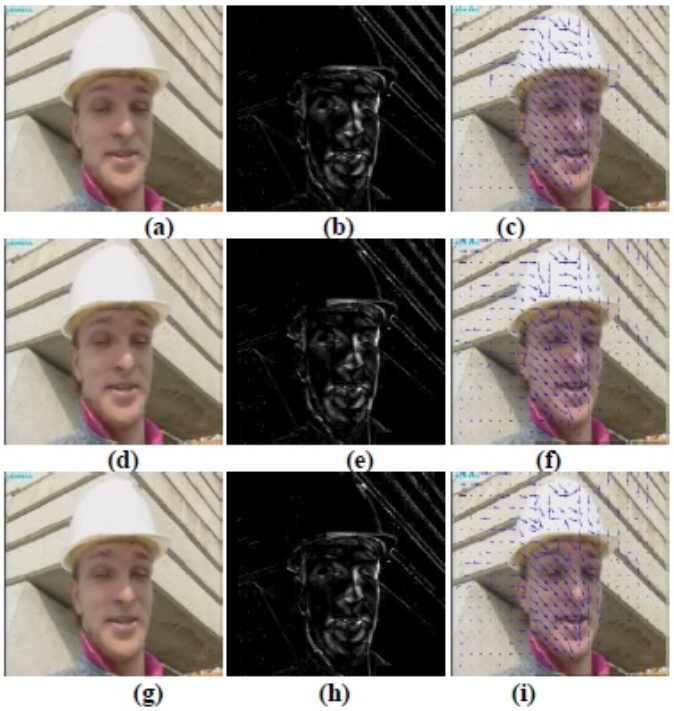

Figure 3: (a)Predicted Frame(FS) (b)Residual(FS) (c) Motion Vector(FS) (d)Predicted Frame(3SS) (e)Residual(3SS) (f) Motion Vector(3SS) (g) Predicted Frame(Proposed) (h)Residual(Proposed) (i) Motion Vector(Proposed)

(C)Taking the search area p=16, b=16

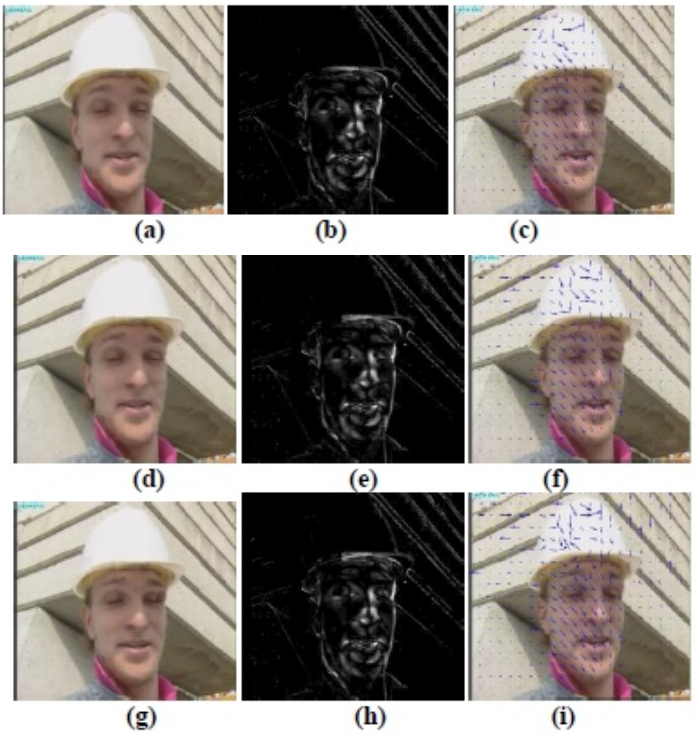

Figure 4: (a)Predicted Frame(FS) (b)Residual(FS) (c) Motion Vector(FS) (d)Predicted Frame(3SS) (e)Residual(3SS) (f) Motion Vector(3SS) (g) Predicted Frame(Proposed) (h)Residual(Proposed) (i) Motion Vector(Proposed)

V. COMPARISION TABLE AND GRAPH

The proposed algorithm implemented in MATLAB software and the comparison is depicted in the table 1

Method	p=8,b=8	p=8,b=16	p=16,b=16
FS	76.1052913297614	76.1750368238704	76.0758449962979
3SS	76.3352060926333	76.3210990470443	76.0638862669877
Proposed	76.6186024523255	76.3895144943009	76.1724994344757

Table 1: PSNR Comparison table for various methods

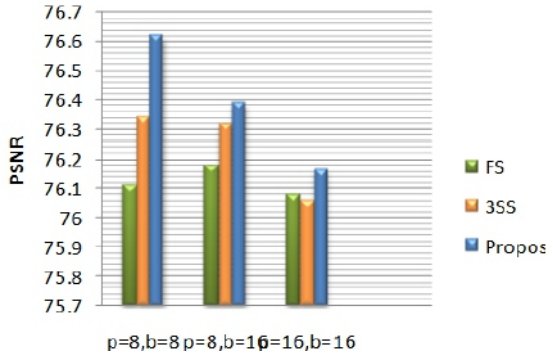

Figure 5: PSNR Comparision chart

VI. CONCLUSION

In table (1) the PSNR value for the different algorithms has been evaluated for various valus of p & b parameters. For p=8.b=8, the proposed fuzzy based method achieves a better PSNR of as compared to full search and three step search algorithms. Thus it can be asserted that the proposed algorithm achieves a better PSNR as compared to other algorithms. The graphical comparison of the PSNR values is shown in figure 5.

FUTURE WORK

In this paper, we have presented the basic building blocks for using the strength of fuzzy logic we are currently approaching to replace the costly motion estimation which causes computationally expensive it affects also the online streaming of data and thus can not be preferred in mobile devices . In future this approach will be more refined and compared the other algorithms with more parameters

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Performance Analysis of Hybrid Precoding in Massive Multiuser Mimo Systems with Different Channels

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ABSTRACT

Massive multiple-input multiple-output (MIMO) is deployed to offer good capacity improvement and performance gain, but at the cost of high complexity of the hardware. In order to implement the task of hardware reduction, a double stage precoding scheme is proposed in this paper to approximate the performance of the well-known baseband zero forcing (ZF) precoding, which is considered generally as an optimum linear precoding methodology in MIMO systems. The proposed hybrid precoding structure which is actually a two-stage precoding is named as Phased ZF (PZF). The principle is that it applies phase-only modification first at the RF processing domain and then the ZF precoding of low dimension is performed on the effective channel as seen from the baseband. The Rayleigh fading channels, sparsely scattered millimeter wave (mm wave) channels and Nakagami-m fading channels are used for simulations of both FC-ZF and PZF all achieving desirable performances.

Keywords - Massive MIMO, Hybrid Precoding, RF Chains, MM Wave, Spectral Efficiency, Fading Channels

I. INTRODUCTION

Data throughput is one of the principal performance statistics in communication systems. high-capacity performance is accomplished using MIMO with basic transmit precoding/receive combination design as shown in [1]-[3]. Channel-state information (CSI) inherently plays a major role in multiuser MIMO systems. For a data communication to occur between base station and user, the channel information is required at the base station. Reciprocity implies that forward channel matrix, so the required channel information may be obtained by the terminals transmitting pilots on the reverse links. These concepts are well illustrated in [1].

Notably, the modest linear precoding methods, such as Zero Forcing (ZF) are optimal and its performance is comparable to non-linear precoding schemes for example very high capacity is realised by dirty paper coding [3]. In conventional MIMO systems multiple antennas are exploited by modifying the complex symbols' amplitudes and phases and then to upconvert it to the carrier frequency after passing it through digital to analog (D/A) converters, mixers and power amplifiers. Outputs from the RF chain are subsequently coupled to antenna elements & each antenna element is to be associated with an exclusive RF chain including DAC converter, power amplifier and so on. Such implementation is uneconomical and expensive in massive MIMO due to large number of hardware and antenna elements.

But low-cost variable quality phase shifters are easily available with current technology, allowing us to apply a high dimensional phase only analog processing as explained in [4]. Full diversity order and near-optimal beamforming performance is obtained by phase only precoding method by applying iterative algorithms. the baseband processing power which is limited can be further exploited to perform multi

stream signal processing as depicted in [6] in which both multiplexing transmissions and diversity in MIMO are addressed with fewer number of RF chains than that of number of antennas. Moreover, multiuser scenario and maximisation of the capacity performance in large array system are not considered. This paper considers the practical hardware constraints of large quantity of RF chains and proposes to design an RF precoder through phase extraction of the conjugate transpose of the overall downlink channel to employ the required considerable array gain in massive MIMO systems inspired by [6]. Low dimensional baseband Zero Forcing precoding is then noticed on the equivalent channel found from the product of RF precoding and the actual RF matrix. This scheme termed as Phased Zero Forcing approaches the performance of the optimal FC- ZF precoding in massive multiuser MIMO scenario as in shown in this paper. Moreover, hybrid baseband and the RF precoding is considered for millimetre wave (mm wave) communications in [9]. They consider the principle of capturing the mm wave channels' "dominant" paths by employing phase control at RF and constrained RF processing, to choose from array output vectors. We also show the simulation of our proposed PZF scheme in mm wave channels achieving desirable performance.

II. SYSTEM MODEL

Massive multiuser MIMO system's downlink communication as portrayed in Fig.1. It typically depicts the communication from a base station to mobile users. Nt number of transmitting antennas is deployed but is driven by K (K Nt). the chain limitation puts a constraint on the highest possible number of transmitted streams to be K, scheduling of

exactly K single antenna users is assumed, where single-stream transmission is assisted by each user. As discussed above, this downlink precoding is distributed between baseband and RF precoding, indicated by F of dimension $N_t \times K$ and W of dimension $K \times K$. at the baseband precoder W, both amplitude and phase alterations are possible, but for the RF precoder F, only phase modifications can be feasible if having phase shifters (variable) and combiners [6]. Each entry of F are normalized to fulfill $|F_{i,j}| = \frac{1}{\sqrt{N_t}}$ Where $|F_{i,j}|$ states the magnitude of (i,j)th element in F.

Adopting narrowband flat fading channel, we obtain the sampled baseband signal arriving at the kth user as

$$y_k = h_k^H FWs + n_k \quad (1)$$

Where h_k^H is the downlink channel from the BS to the kth user and $S \in C^{K\times 1}$ denotes the signal vector for the total of K users, satisfying $E[SS^H] = \frac{P}{K} I_k$

Where P is the transmission power at base station and E[.] is the expectation operator. Due to the power constraint of total transmitted power, W is normalized to satisfy $\|FW\|_F^2 = Kn_k$

Where n_k denotes the additive noise, assumed to be circularly symmetric gaussian with unit variance i.e., $n_k \epsilon N(0,1)$. Then, the received signals to interference plus noise ratio (SINR) at the kth user is derived to be:

$$SINR_K = \frac{\frac{P}{K}|h_k^H FW_k|^2}{1+\sum_{j\neq k}\frac{P}{K}|h_k^H FW_j|^2} \quad (2)$$

Where the jth column of W is represented by W_j. if gaussian inputs are used, the system can achieve a long-term average (over the fading distribution) spectral efficiency given by:

$$R = \sum_k^K E[\log_2 1 + SINR_k] \quad (3)$$

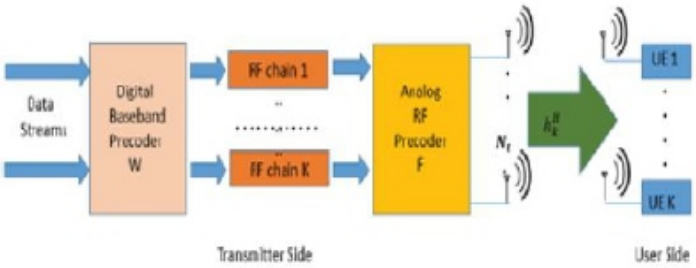

Fig. 1. System model of the hybrid precoding structure in downlink communication

III. HYBRID PRECODING IN MASSIVE MIMO SYSTEMS

In massive MIMO systems ZF precoding is a prominent linear precoding scheme to get good capacity performance because of the asymptomatic orthogonality so the user channels in richly scattering environment as explained in [3]. In ZF precoding the baseband precoding is executed that requires Nt RF chains that performed A/D conversion and RF frequency translation. The main target while performing is to make the orthogonalization between different users' channels in order to eliminate interference which in turn also means that the orthogonality determines the antenna gain [5]. Two random channels usually have correlation between them and the correlation between them lead to power loss. Therefore, the antenna gain is related to the correlation between different users' channels.

To relieve the hardware constraints in realizing the full potential of massive MIMO systems, we propose to apply phase only control to couple the K RF chain outputs with the Nt antennas, employing the cost-effective RF phase shifters. Then, multi-stream processing of a lower dimension is done at the baseband to remove unwanted interferences.

The proposed low-complexity two-stage hybrid precoding scheme, also called as the phased-ZF (PZF) is shown to approximate the performance of full-complexity ZF precoding which is economically very infeasible due to large number of components required. The spectral efficiency achieved from the proposed PZF is also analysed.

A. Hybrid Precoder Design

The implementation of the proposed hybrid baseband and RF processing is shown in Fig. 1, where W modifies both the phase and the amplitudes of the incoming complex symbols whereas the RF precoder F takes the control of the phase of up-converted RF signal. We try to control and modify the symbols' phases only in RF domain through phase extraction of the conjugate transpose of the downlink channel from the base station to multiple users. It is done to align the phase of the channel elements and thus can provide the large array gain that is aggregated by the antennas in massive MIMO systems. Stated clearly, denote Fi,j as (i,j)th element of F and we perform the RF precoding according to

$$|F_{i,j}| = \frac{1}{\sqrt{N_t}} e^{j\varphi_{ij}} \quad (4)$$

Where, The (i,j)th element of the conjugate transpose of the compound downlink channel is represented by φ_{ij} i.e. $[h_1,h_2,\ldots\ldots,h_K]$.

Here, we inherently assume perfect knowledge of the channel in the Base station which can possibly be obtained e.g., by the combination of uplink channel estimation and theory of channel reciprocity in time division duplex (TDD) systems as explained in detail in [1].

Then at the baseband, we have an equivalent channel H_{eq} = HF of a lower dimension K × K where $H = [h_1,h_2,\ldots\ldots,h_K]^H$ represents the composite downlink channel. So, baseband precoding with multiple-stream can be applied to H_{eq}, where low-dimensional ZF precoding is performed as

$$W = H_{eq}^H \left(H_{eq} H_{eq}^H\right)^{-1} \lambda \qquad (5)$$

Where, λ is the diagonal matrix, proposed for normalization of column power. The reduction in hardware complexity can be seen in concurrent transmission of multiple streams (K) using PZF where K RF chains are required as compared to FC-ZF precoding (N_t).

B. Spectral Efficiency Analysis in Rayleigh Fading Channels

In this part, the spectral efficiency is analysed for both PZF and full-complexity ZF precoding for the large antenna size Nt, assuming Raleigh fading. What roles different parameters play in affecting system capacity in also revealed by deriving closed-form expressions.

Denoting the k^{th} column of F by f_k, we get:

$$y_k = [h_k^H f_1, h_k^H f_2, \ldots, h_k^H f_K] W_s + n_k \qquad (6)$$

Based on [1]. As discussed before, f_K is designed by extracting the phases of h_K, and thus, we have the diagonal term

$$h_K^H f_K = \frac{1}{\sqrt{N_t}} \sum_{i=1}^{N_t} |h_{i,k}| \qquad (7)$$

Where, The ith element of vector h_k is represented by $h_{i,k}$. It is assumed that each and every element of h_k is independent and identically distributed (iid) complex gaussian random variable with zero mean and variance of unity i.e. $h \in N(0,1)$ and it is concluded that $|h_{i,k}|$ follows Rayleigh distribution with mean $\sqrt{\pi}/2$ and variance of $1 - \pi/4$. For N_t tending to infinity, the central limit theorem indicates

$$h_K^H f_K \in N(\sqrt{\pi N_t}/2, 1 - \pi/4) \qquad (8)$$

For the off-diagonal term, i.e., j ≠ k we have: $h_K^H f_j = \frac{1}{\sqrt{N_t}} \sum_{i=1}^{N_t} h_{i,k}^* \, e^{j\varphi_{ij}}$

Where, (.)* denotes the complex conjugation. The off-diagonal term $h_K^H f_j$ in Rayleigh fading channels is distributed according to $h_K^H f_j \in N(0,1)$. We can also derive that the magnitude of this term follows the Rayleigh distribution with

mean $\sqrt{\pi}/2$ and variance $1-\pi/4$. This term is negligible when compared with the diagonal term eqn. (8) when transmit antenna number is very large (N_t). it implies that the inter-user interference is essentially insignificant even when lacking baseband processing for large N_t. for intermediate high values, the residual interference still degrades the system. Therefore, we apply ZF precoding at the baseband for suppressing it as in (5). The spectral efficiency accomplished by PZF is upper bounded by KR' with: $R' = E[\log_2(1+\frac{P}{K}|h_K^H f_K|^2)]$

Which can be explained by theorem given below.

Theorem 1: The upper bound of the spectral efficiency attained from PZF precoding method is given by $R_{PZF} \leq KR'$ where

$$\lim_{N_t\to\infty} \frac{R'}{\log_2(1+\pi P N_t/4K)} = 1 \qquad (9)$$

Proof: the per-user upper bounded is derived as $R' = E[\log_2(1+\frac{P}{K}(y+\frac{\sqrt{\pi N_t}}{2})^2)]$

Which is simplified to be: $R' = \log_2\left(1+\frac{\pi N_t P}{4K}\right) + E[\log_2(1+\frac{\frac{P}{K}\left(y+\frac{\sqrt{\pi N_t}}{2}\right)^2}{1+\frac{\pi N_t P}{4K}})]$

Where, the term $E[\log_2(1+\frac{\frac{P}{K}\left(y+\frac{\sqrt{\pi N_t}}{2}\right)^2}{1+\frac{\pi N_t P}{4K}})]$ can be written as Δ as $\lim_{N_t\to\infty} \Delta = 0$ and $y \in N(0,\sigma^2)$ with $\sigma = \sqrt{(1-\pi/4)}$ showing that Δ is both upper and lower bounded by zero in the limit.

B. Spectral Efficiency Analysis in Rayleigh Fading Channels

In this part, the spectral efficiency is analysed for both PZF and full-complexity ZF precoding for the large antenna size Nt, assuming Raleigh fading. What roles different parameters play in affecting system capacity in also revealed by deriving closed-form expressions.

Denoting the k^{th} column of F by f_k, we get:

The full complexity ZF precoding vector (with unit norm) for the Kth stream follows by projecting onto the null space of $H_K' = [h_1, h_2, \ldots\ldots, h_K]^H$. due to the users channels being asymptomatically orthogonal in massive multiuser MIMO full complexity ZF precoding converges to conjugate beamforming with inter-user interference forced to zero, attaining $SINR_K = P/K(|h_K|^2)$, as N_t tends to infinity. Then, we obtain the spectral efficiency of complete-complexity ZF precoding for major N_t values as in [7].

$$R_{FC-ZF} = KE[\log_2(1+\frac{P}{K}|h_K|^2)] \qquad (10)$$

After simplification of the Eqn. (10). $R_{FC-ZF} = Ke^{KP}\log_2 e \sum_n E_n\left(\frac{K}{P}\right)$

By acknowledging that $|h_K|^2$ follows chi-squared distribution with $2N_t$ degrees of freedom and $E_n(x)$ is the exponential integral of the order n.

IV. MM WAVE COMMUNICATION CHANNELS

Mm wave communication has very limited multipath components and they are based on small cell antennas which is perfect for massive MIMO. We apply and extend our proposed PZF precoding in mmWave massive MIMO systems considering geometric channel model in [9].

$$h_k^H = \frac{\sqrt{N_t}}{\sqrt{N_P}} \sum_{l=1}^{N_p} \alpha_l^k \, a^H(\phi_l^k, \theta_l^k) \qquad (11)$$

Where each is assumed to observe the same number of propagation paths denoted by N_p, $a(\phi_l^K, \theta_l^K)$ is the array response vector and the α_l^K represents the strength associated with the lth path seen by nth user. ϕ_l^K is the random azimuthal or elevation angle of departure drawn independently from uniform distributions in $[0,2\pi]$.

V. SIMULATION RESULTS

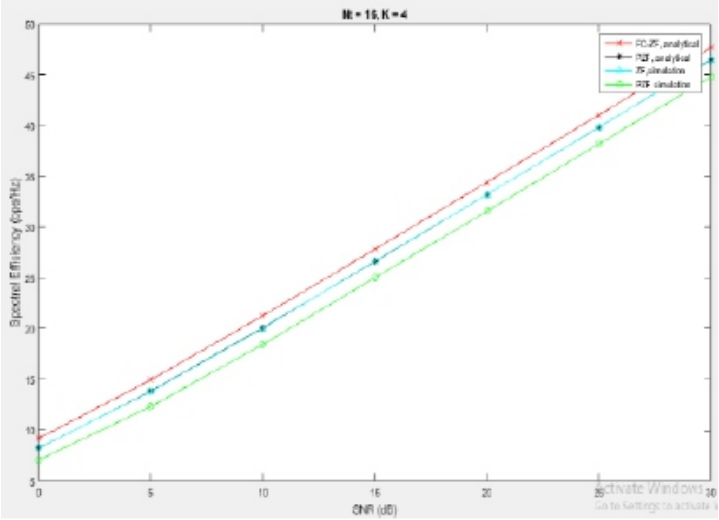

Fig. 2. Spectral efficiency plots for FC-ZF and PZF precoding methods in large multiuser MIMO systems amid rayleigh fading channels with Nt = 16 and K = 4 obtained from 1000 channel realizations.

For all simulations, two assumptions are made one of perfect channel state information and secondly of one receiver antenna per user. Firstly, the analytical and simulation results are plotted for complete complexity ZF precoding and the low complexity PZF and compared in terms of spectral efficiency for different K and Nt. as Nt increases, the performance of PZF approaches full complexity ZF then the simulations are carried in nakagami-m fading channel for different values of small m. we know that for Rayleigh distribution, m = 1, for rician distribution, m>1 and for hoyt distribution, m <1 [5]. Finally, spectral efficiency of complete complexity RF and PZF are plotted in mmWave several user channel.

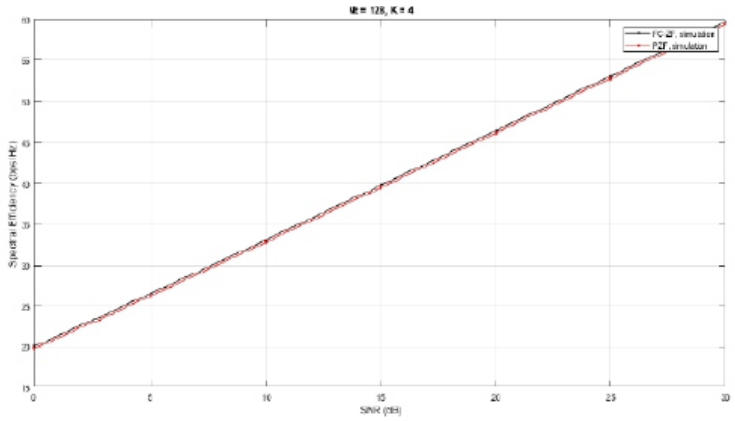

Fig. 3. Spectral efficiency plots achieved from FC-ZF (black line) and PZF (red line) precoding in large multiuser MIMO systems using rayleigh fading channels with Nt = 128 and K = 4 obtained from 1000 channel realizations.

VI. CONCLUSION

In this paper, our objective was to analyse the precoding techniques to mitigate inter user interference problem present in multiuser MIMO systems through an initial software model. These were tested under different multi-user scenarios with different levels of success. The proposed scheme performs fairly in all channels, namely, nakagami-m fading channel, Rayleigh fading channel and in mmWave channels.

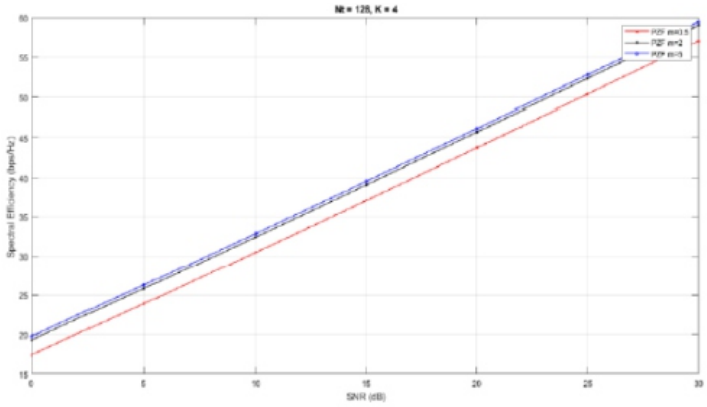

Fig. 4. Spectral efficiency plots achieved by PZF precoding methods in large multiuser MIMO systems amid nakagami-m (m=0.5 (red),2 (black),5 (blue)) fading channels with Nt = 128 and K = 4 obtained from 1000 channel realizations.

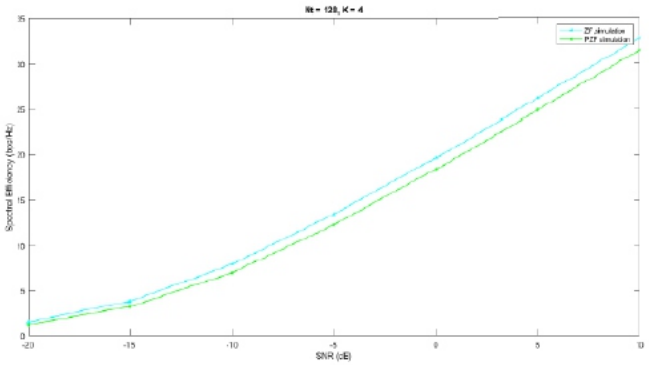

Fig. 5. Spectral efficiency plots achieved by ZF (blue) and PZF (green) precoding methods in large mmWave multiuser systems having Nt = 128 and K = 4 spacing d = ½ and NP = 10 obtained after averaging of 1000 channel realizations.

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Real Time Smart Attendance Maintenance System Based on PCA and Eigen Face Recognition Technique

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A B S T R A C T

Attendance maintenance can be burdensome task if done manually. Face recognition is promising biometric technique to help avoid proxies thereby facilitating real time smart attendance management. Unlike other biometric techniques like iris, palm or fingerprint , face recognition is a non intrusive process. The technology is getting widely used in criminal detection, face tracking, airport security, and forensic surveillance systems. This paper proposes Eigen face based PCA algorithm for face recognition. This face recognition system recognizes the faces in a web-cam or from an existing database, and these face images are then tested on the basis of descriptive features with a training image dataset. Matlab Image Processing toolbox is used for Image processing.

Keywords - Eigen faces, PCA, Face Recognition, Image Processing.

I. INTRODUCTION

One of the easiest and most successful PCA techniques used in facial recognition systems is the eigenface technique. This method converts faces into limited set of essential features called eigenfaces which act as the principal components of the preliminary training set (learning images). Recognition is achieved by projection of a new image onto eigenface subspace, after which the individual's position in the eigenface space is compared with the one of known individuals . The benefit of this technique over other systems of face recognition lies in its speed, simplicity and insensitivity to facial changes that are minor or incremental. But the Images need to be frontal vertical views of human faces. The reasons for choosing eigenface method for face biometrics are:

- It is independent from the geometry of the face.
- The ease of realization without requiring special hardware.
- The speed and simplicity of recognition compared to other methods.
- The higher rate of performance relative to other approaches.

II. TRAINING ALGORITHM:

1) Consider an ensemble of m (training) images of N*N dimensions.

$$x_1, x_2, x_3 \ldots x_m.$$

2) These images are converted into vectors of dimension N2 *1.

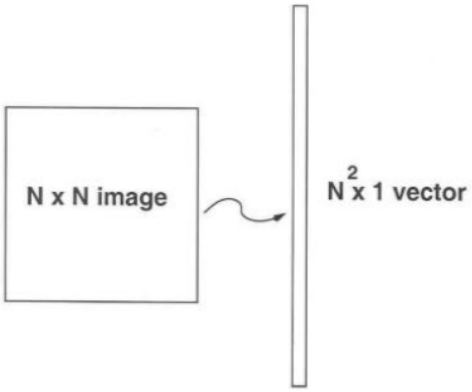
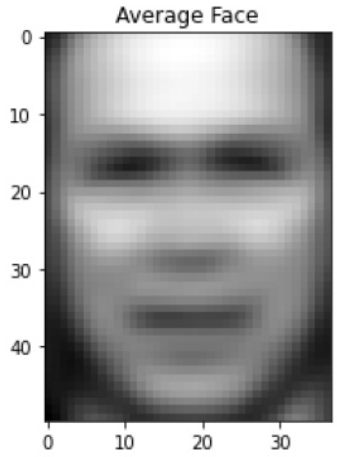


Fig 1: Image conversion into vectors of dimensions N^2*1.

3) Now the average of these face vectors are calculated and subtracted from each vector.

$$\psi = \frac{1}{m}\sum_{i=1}^{m} x_i \quad (1)$$

$$a_i = x_i - \psi \quad (2)$$



4) Now all the face vectors are taken to get a matrix of size N^2 * M .

$$A = [a_1 a_2 a_3 .. a_m] \quad (3)$$

5) Covariance matrix is computed by multiplication of A with A^T.A's dimensions are N^2*M, so A^T „s dimensions are M * N^2. On multiplying we get a N^2*N^2 matrix giving N^2 eigenvectors of size N^2 which are not computationally feasible. That's why covariance matrix is obtained giving M * M matrix with M eigenvectors of size M (assuming M << N^2).

$$Cov = A^T A \quad (4)$$

6) Eigen values along with eigenvectos of the given covariance matrix is calculated using following formula :-

$$A^T A v_i = \lambda_i v_i \quad (5)$$

$$A A^T A v_i = \lambda_i v_i \quad (6)$$

$$C' u_i = \lambda_i u_i \quad (7)$$

where,

$C' = AA^T$ and $u_i = A v_i$.

Hence it can be inferred that C' and C share same eigenvalues. Their corresponding eigenvectors are related by $u_i = Av_i$. M largest eigenvectors(and eigenvalues) of covariance matrix provides M largest eigen vectors (and eigen values) of C' .

7) Eigenvector and Eigenvalues for the reduced covariance matrix are calculated and mapped into C' by using $u_i = Av_i$.

8) K eigenvectors (size N2) of C' are chosen corresponding to K greatest eigenvalues ($K < M$).

9) Eigen vectors so obtained are used in this step.

Training faces (normalised average face) xi are taken and each face vector is represented as the linear combination of best K eigenvectors as illustrated below:-

$$x_i - \psi = \sum_{j=1}^{K} w_j u_j \qquad (8)$$

Uj= **EigenFaces**

10) Eigenface coefficient are taken and training faces are represented as vector for these coefficients.

$$x_i = \begin{bmatrix} w_1^i \\ w_2^i \\ w_3^i \\ . \\ . \\ w_k^i \end{bmatrix} \qquad (9)$$

III. TESTING/DETECTION ALGORITHM

1) A test face y need to be preprocessed first to align it in the centre of the image and should possess same dimensions as that of the training face. The face is now subtracted from average faceψ .

$$\phi = y - \psi \qquad (10)$$

2) The normalized vector is now projected onto eigenspace and a linear composition of eigenfaces is obtained.

$$\phi = \sum_{i=1}^{k} w_i u_i \qquad (11)$$

3) From the aforementioned projection, coefficient vector is generated such that

$$\Omega = \begin{bmatrix} w1 \\ w2 \\ w3 \\ . \\ . \\ w6 \end{bmatrix} \qquad (12)$$

4) The vector so generated is subtracted from training image and the least distance between training and testing vectors is obtained.

$$e_r = \min_l \| \Omega - \Omega_l \| \quad (13)$$

5) If er is less than tolerance level i.e. Tr, then the face is recognized as l face from training set else it is shown as unmatched.

IV. EXPERIMENTAL RESULTS

After calculating the weights for all 80 testing images as discussed earlier , the euclidian distance of each testing image weight with all the other testing image weights is taken and compared with the threshold. Already calculated distances are not taken in the next iteration. So , a total of 3160 combinations are taken.

$$C(n,r) = C(80,2) = \frac{80!}{2!(80-2)!} = 3160$$

The experimental data consist of a self made database including 20 images per person. In each group 16 images were selected for training set , the residual images were used for testing , so there were 320 training images and 80 testing images. The images were captured from a webcam under different illumination, resolution, expression, pose/alignment and occlusion variations.

In the proposed method illumination variations include images captured under fluorescent lamp, LED light bulb, dim light and dark background. Resolution range considered is :
MJPG_1280*720, MJPG_848*480,
MJPG_960*540, YUY2_160*120,
YUY2_320*180, YUY2_320*240,
YUY2_424*240, YUY2_640*360,
YUY2_640*480.

Expression variation included images captured with eyes close, mouth wide open, smiling and laughing. Alignment/pose variations include side tilt, side face, head facing up and head facing down images.

Occlusion variations included images with accessories such as mask, cap and glasses.

If the face is present in the dataset and the system correctly verifies it then it is said to be true positive (TP). If the face is present in the dataset and the system incorrectly verifies it then it is said to be false positive (FP). If the face is not present in the dataset and the system correctly verifies then it is said to be true negative (TN) and if the face is not present in the dataset and the system incorrectly unverifies it then it is said to be false negative (FN) .

$$TPR = \frac{TP}{TP+FN} \quad (14)$$

$$FPR = \frac{FP}{FP+TN} \quad (15)$$

Accuracy is determined by,

$$Accuracy = \frac{TP+TN}{TN+FP+TN+FN} \quad (16)$$

The accuracy is found to be 94.33%. Training time is found to be 68.543 sec.

Average testing time is is 0.12 sec.

Fig 3 : Matching images with the database

V. CONCLUSION

A self made database was created by capturing images in real time environment. This algorithm was extensively trained and was found performing fairly well using a multitude of test images under varying conditions and variables. All the work described above included real time data. The recognition accuracy was found to be 94.33%. Another method like ANN, CNN, facenet embeddings , wavelet scattering transform detection alignment pipeline with viola jones or any other such methods can be integrated with it to achieve better accuracy under unconstrained environment. Also another modality such as voice can be combined with face to achieve a more robust authentication.

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Hydrophobicity Class of Porcelain Insulators Base on Method of Contact Angle Via Image Processing

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ABSTRACT

We present an energetic and precise data of contact angle measurement by followed the standard IEC TS 62073-2016 [1] and build on by bringing knowledgeof an image processing to analyze that capitalizes on the transform image data of droplet water on porcelain insulator to indicate the Hydrophobicity Class and go through a variety of processes to achieving powerful and effective results. We show that various contact angle measurement problems can be treated in principle method that use an image processing approach. This method is a part of experiment for analyze data and provides a principled way to solving contact angle measurement in various settings. Moreover, the image processing applications enable to quantify and relate these properties in a mathematical function were found, that could be used in the field by the electrical companies because no human errors are detected and can add conditions to improve algorithm.

Keywords - Contact Angle Method, Image Processing, Hydrophobicity Class, Insulator

I. INTRODUCTION

The demand for the electrical power systems is increased. The security system problems in the power grid are therefore at risk and more serious damage. For electrical insulators are used to all grid system [2 - 3]. At present, there are studies and testing of the effect of the environment on insulators such as operating temperature, UV rays, acid rain or chemicals, salt cough level, humidity and mist including contaminants on the insulator surface. All resulting in the insulating property of the insulator deteriorated, which is resulting in reduced hydrophobic properties. It will affect the service life of insulators the breakdown on the insulator surface is directly related to the insulating surface. While the insulator surface is dry, the impurities will be difficult to adhere to the surface of the insulator. Therefore, insulators will still be insulated and not much effect on the surface resistance of insulators but in wet or humid surface conditions the contaminated matter can combine with water. Then become a conductor on the surface of the insulator, thus causing flashover on the surface [4-5].

Accordingly, this article focuses on the analysis of the effects of hydrophobic levels. The RTV coated porcelain insulatorsabout [6]. In which the test, there are unclear for test conditions. So, it is impossible to test accurate data such as constant lighting at the best view of water droplets ontheinsulator surface or method of measurement that have deviations from the testers, etc [7-9]. This paper has used the image processing principle applied to the test by the Contact angle method to be able to summarize the test results for classification hydrophobicity class to find ways to develop from paper that has been made with effective results image and in accordance with the established standards.

Name	Contact Angle Method
Colour Transformation	•
Edge Detection	•
Noise Reduction	•
Morphological Operation	•
Curve Fitting	•

Table1: The experimental process table.

II. DETAILS EXPERIMENTAL

2.1. Related Works

From the study of the hydrophobic level of insulators, by studying the various research references applied and further developed by designing and installing a test kit. Then, test each experiment, analyses the data and conclusions. Which the image processing algorithm used to analyze the test results. The details of the process used for testing by the Contact Angle measurement is given in Table 1.

2.2. Equipment

Our method for measuring the contact angle. In the design and installation of the test kit as shown in Fig. 1. Space is calculated with 50 × 100 × 90 cm in size so that the experiment kit can support different types of insulators as follows: Class 52-X, 53-X, 54-X, and 57-X. Automatic sliding rail sets for precise control of testing distances and lighting for optimal lighting orientation.

2.3. Contact Angle Methods

This method is a measurement that involves the evaluation of the contact angle formed between the edge of single droplet of water and the surface of a solid material. It can be measured only when a drop of water is placed on the desired horizontal surface, the advancing and receding contact angle can be measured

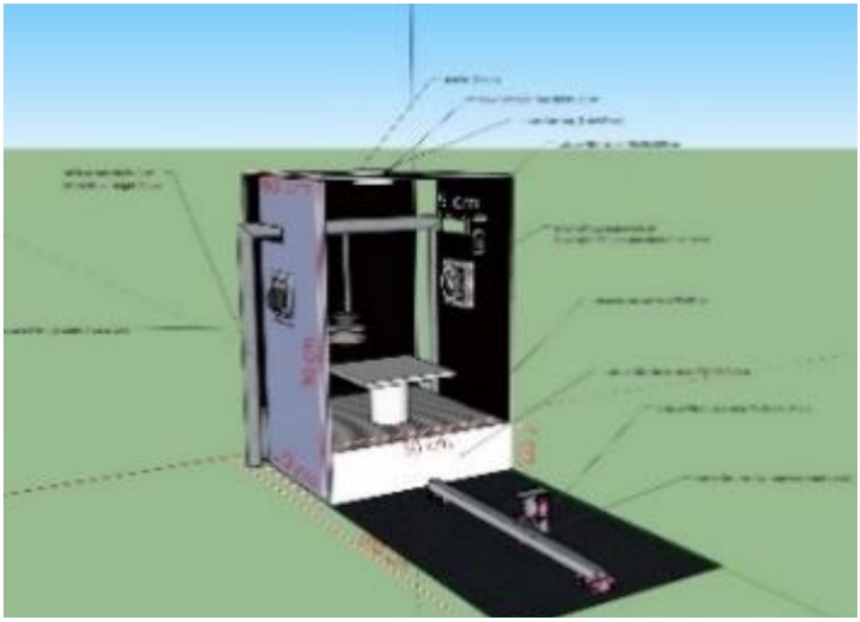


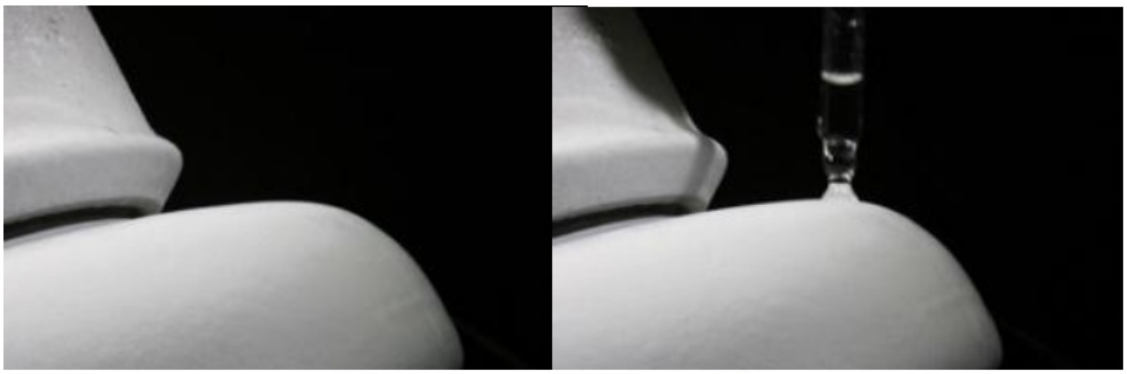
Fig. 1. 3D design of the test kit.

by adding water to or withdrawing water from the droplet.

The contact angles depend strongly on the surface ruggedness and contact measured on polluted surfaces may differ significantly from contact angle measured on smooth, clean, and planar surfaces.

III. EXPERIMENTAL DESIGN

When performing the experiments [1] from the set of experiments that have been created, the results are as follows in Fig. 2.



2A) 2B)

Fig. 2. The figure has capture of before and after water droplets on the insulator.

The Contact Angle Method via Image Processing, From the test results of measuring the angle of contact between water droplets on the insulator surface of the insulator with RTV coating, so the picture can only see the insulator and the photos taken can see water droplets on the insulator surface. Which will be further analyzed via image processing as follows:

1. Import image data file into program. Since the image is RGB data, there will be 3 layers of overlapping. Therefore, the image will be converted to only one layer via Color Transformation. Then, for each pixel of the gray scale image, if its value is lesser than the threshold, then we assign to it the value 0 (black). Otherwise, we assign to it the value 255 (white).
2. Using Edge Detection with Sobel principle, the result will be logical data collection (0,1), which will make the image processed into black-and-white images. The white pixel represents the edge of Objects inside the image.
3. The data was processed through Edge Detection with Pixel valuable deviate from normal. As a result of the distortion of the image file. Therefore, by improving the way information Noise Reduction through determining factor in improving data and variable threshold to figuring out a series of changes.

Then It will make the pixel missing along the edge of the image. Which can lead to discrepancies in the subsequent processing times. Therefore, there are ways to improve data quality by using Morphological Operation, which is a method of filling - reducing the details of the image as shown in Fig. 3.

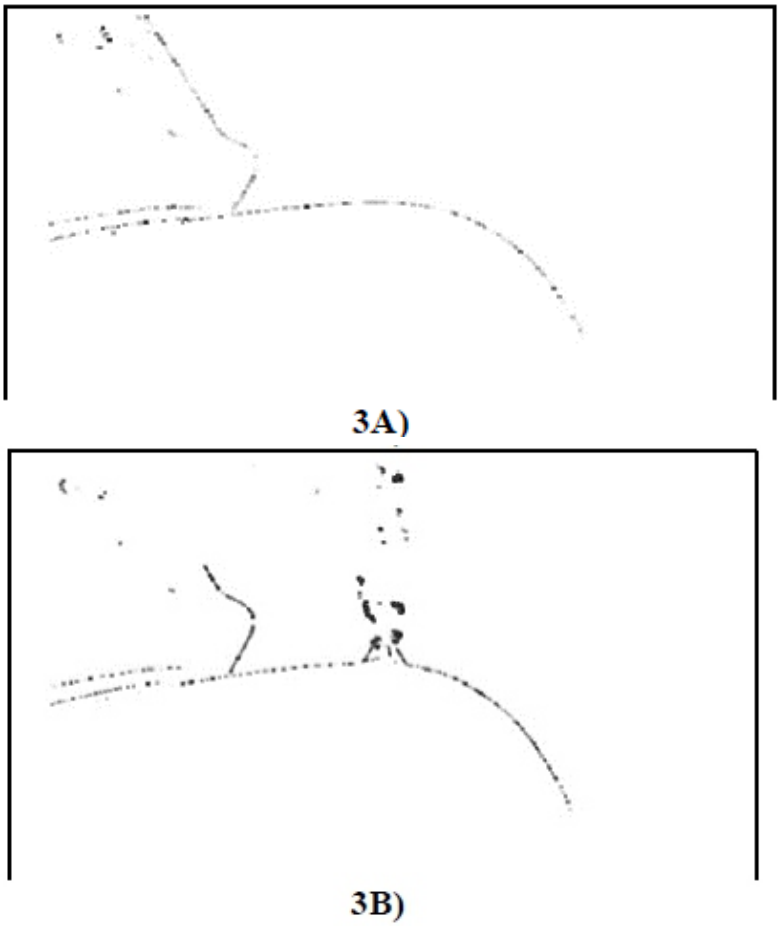


Fig. 3. The result an image before 3A) and after 3B) droplet water by using Edge Detection, Noise Reduction and Morphological Operation

4. The purpose of this part is to find the Contact Angle. We cut the area of the surface insulator's edge to a certain size to prepare for the application of the tangent equation as shown in Fig. 4.

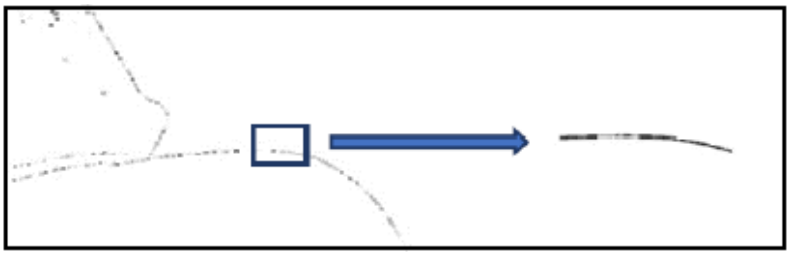


Fig. 4. Crop an image to find the equation for that curve.

5. After reducing the size of the photo, see only insulators. Then want to know the curvature of the insulator border, which must find the equation for that curve to come out by going through the Curve Fitting process to find the curve equation. It will be a way to select a polynomial curve. The Curve will pass the data group in which the sum of the distance from each data point is the least. The Curve Fitting process will use the Curve Fitting to analyze the equation from the Fig. 4 and from the surface of the insulator is not very complex. Therefore, choosing to use the 2nddegree equation to return the coefficient for the polynomial p (x) of the nth degree that is most suitable for at least squares for the data in y and the coefficient of p to the power down. And the length of p is n + 1.

+6. Take the curve equationfrom the Surface line plot on the surface insulator, then make the Offset line to offset the surface line up by 5 pixels on the y-axis to check the initial and the end touch point When defining all 4 points A (x1, y1), B (x2, y2), C (x3, y3) and D (x4, y4). In point A and C are the intersection between the Surface line and the water drop of the left and right side. And point B and D are the intersection between the Offset line and the water drop of the left and right side.

7. When the point of beginning (point A and C) and the end point of the water stops(point B and D) on the surface. then create the condition of linear equation to create the tangent of the two points on both the left-and right-hand side to find the angle of contact between the insulator and water droplets from the setaRLeft and setaRRight variables. To find the answer, we use to get the average variable of setaRLeft and setaRRightto create variable setaRMean. That is the answer ofhow the Contact Angle method as shown in the Fig. 5.

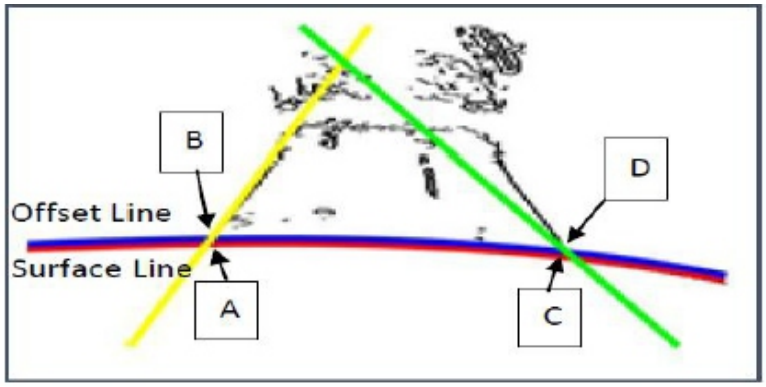


Fig. 5. The results of image processing (The Contact Angel Method).

8. Check the answer that this type of insulator has a level of Hydrophobicity by checking as shown in the Table 2.

Topic	Angle
The Receding Contact angle (θ_r) Left side [setaRLeft]	60.2551
The Receding Contact angle (θ_r) Right side [setaRRight]	48.0128
The Receding Contact angle (θ_r) Mean [setaRMean]	54.1340

Table2: The result of the receding contact angle in an experiment table.

That can be considered from the table in the standard IEC TS 62073-2016 [1], the result is the setaRMean variable from the sample is 54.134 degrees. This insulator is in Hc2.

IV. RESULTS

After design the experiment result, We can test our method by using the porcelain suspension insulator 52 - 1 by means of contact angle measurement. Which uses water droplets of about 50 milligrams on the surface of the insulator type porcelain insulator 52-1, coated with RTV. The results of the test can be shown in graph as Fig. 7.

	Area 1	Area 2	Area 3
1st Insulator	54.134	46.5064	60.2499
2nd Insulator	65.0151	53.2522	56.3099
3rd Insulator	52.2351	46.5064	60.2499

Fig. 7. Graph showing the data of the mean receding contact angle 3 area per insulator.

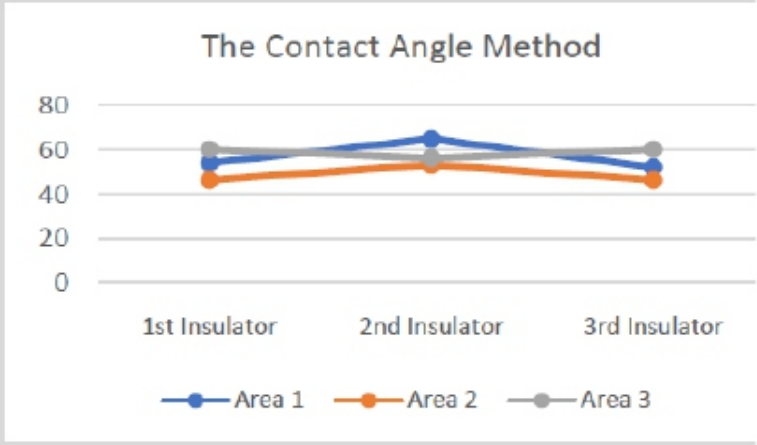


Fig. 8. Graph showing the result of the Contact Angle Method

Then find the average value of each insulator. as follows:

1. Test insulator 1 has an average contact angle of about 53.6301◦
2. The test insulator 2 has an average contact angle of about 58.1924◦
3. Test insulator 3 has an average contact angle of about 55.3455◦

When comparing the test results, it was found that insulators with RTV coating can evaluate Hydrophobicity Classification. Which has a hydrophobic level from the visual observation and the use of image processing to help classify Classification. Which has a hydrophobic level of 6 Class. It can be concluded that Insulators with RTV coating have a harder wetting surface than HC with a higher-class number than HC 2 and have a wetting surface more easily than HC with a class number lower than HC 2. Therefore, water droplets can adhere on the floor. Good skin texture. In accordance with the standards of IEC TS 62073-2016 [1].

V. DISCUSSION AND CONCLUSION

In the test has built a set of devices for testing the Contact angle measurementin accordance with the requirements of the IEC TS 62073 – 2016 [1]. Included as a test set for only one specimen. After that, doing an experiment and take the experimental results into consideration by considering that will be analysis of experimental results by image processing method for measuring the contact angle of water droplets on the insulator surface. The selection of this method used in the application to image processing because of the characteristics of the test. If analyzing the test results by the tester itself, there will be a problem with the error from the tester. Therefore, the analysis of contact angle determination and classification of the Hydrophobicity Class requires measurement resolution. Due to the characteristics of water droplets are similar. The visual analysis results in the possibility of error and ultimately lead to incorrect results. We can classify the topics studied and apply as follows:

1. Color Transformation
2. Edge Detection
3. Noise Reduction
4. Morphological Operation
5. Curve Fitting.

From the test results, it is found that the equipment is usable in hydrophobic testing. and can be concluded that method of measuring the Contact Angle Method. The insulator with RTV has a Receding Contact Angle between 40 ° and 60 °. Where the surface of the insulator will have only a slight drop of water in contact with the surface and has the characteristics of dew drops. Therefore, can be evaluated at the HC 2 level, which shows the level of High hydrophobicity. So, it can be estimated at the HC 2 level. which shows the level of at high hydrophobicity, the surface of the insulator is therefore hydrophobic. From the experiment, the RTV coating on the insulator surface. As a result, in insulators having the level of hydrophobic (High hydrophobicity) that drops of water will adhere to the surface of the insulator or the surface of the insulator is difficult to get wet, which causes the skin flashover is caused by insulators in wet or humid skin conditions and contaminated with water to become a conductor on the surface of the insulator.

The further work, in image processing, precision can also be improved in terms of adjusting the parameters that are part of the noise reduction, which will be developed in the future.

ACKNOWLEDGEMENT

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Design and Implementation of Cost – Efficient Home Energy Management System

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ABSTRACT

This paper presents the cost-efficient home energy management system (EMS). The use of energy management system can provide reducing the energy usage in an effective way and also leading to cost saving efficiently. The design and development of an intelligent monitoring and controlling system for home appliances in a Real time method is presented in this paper. Some of them include: time of use (ToU) pricing can have three values low, average, and high depending on the peak situation. real time pricing (RTP) is communicated to end-users on an hourly basis. This system primarily observers the electrical parameters such as voltage and current and subsequently calculates the power consumption of the home appliances that are needed to be monitored. This EMS is comprised the ZMPT 101B, ACS 712 and 4channel relay. DS3231RTC module is used to get the amount of electricity consumption with date and time. Arduino ATmega328 is using to control the home appliance's voltage and current. And then it is used to notify from overusing electricity condition and display on LCD. GSM modem is used to send short message to household owner when the consumption unit level is greater than threshold unit level. SD card is used to store the data of the power consumption unit. In order to be clearly seen the effectiveness of our home energy management system, here the comparison of home energy consumption with and without EMS is done. Accordingly, it also states that this EMS can save 50% of electricity cost.

Keywords - Power, Real Time Pricing, Time of Use Pricing, Energy Management System, Cost, GSM Modem

I. INTRODUCTION

Energy management system is one of the major issues affecting the power sector of any economy. For the purpose of growing energy efficiency, reducing energy costs. [1]. The purpose of using this development based on Energy Management System technology which is used to reduce and manage home energy usage. Also this work will provide evidence to the household owner about the effectiveness of the developed energy management system in reducing electricity bill and cost savings. [2] Many of the electrical devices used in homes do not improve energy consumption, or to automatically or semi automatically manages the use of electricity in the home. [3] From the electrical point of view, the complete power consumption for a home can be determined by using EMS technology however the energy consumption of the different devices cannot be exclusively identified and observed. [5] HEMS has been developed to operate home appliances in an ideal methodology. [6] The researchers studied the smart heating, ventilation and air conditioning scheduling method that considers home resident convenience and characteristics of the thermal device and an optimization based approach to minimize the cost in Home Energy Management System (HEMS). They described heating, ventilation, air-condition, (HVAC) model that considers the convenience of the home resident and a method to solve the scheduling problem with a model for HEMS. [7] Thus, they focused their study on temperature control in home. Also, they proposed an algorithm that provides an optimal scheduling of energy resources and avoids inconvenience to the home resident. Furthermore, this resulted to HVAC energy consumption

reduction. [8] Their method was expected to reduce the cost for household owners because it can be applied to a variety of home environments.

The rest of this paper is organized as follows. Section I contains state of the art of the home energy management system, section II presents organization to collect information data, section III classification of loads for the planned model, section IV presents the experimental results of the energy management system and section V has conclusion.

II. HOME ENERGY MANAGEMENT SYSTEM

According to the literature review, their method does not estimate definitely the proportion of that energy is being wasted. Their system did not calculate the amount of electricity consumption's cost per week for home appliances' usage before monthly electricity bill comes out.

To overcome this kind of problem, in this research, our EMS system provides the weekly electricity bill in order to be able to check and control the amount of home electricity consumption. It is intended to be a part of a smart home system. The EMS system may not only reduce electric consumption and cost, but also provide safety. In this system, the amount of electricity consumption of home appliances is limited for a week, and the household owner can control and adjust that consumption amount according to his demand. The main focus of this system is to develop an algorithm for keeping the households' energy consumption to be lower than a limit specified by the household owner.

A. System Block diagram

Figure 1 shows the block diagram of home energy management system. It comprises two main parts: the measurement of electrical parameters and the energy management of home appliances.

The amount of electricity usage and consumption in homes has considerably increased due to economic growth. More and more people invest in appliances such as TVs, refrigerators, air conditioning system, electric stoves, and computers.

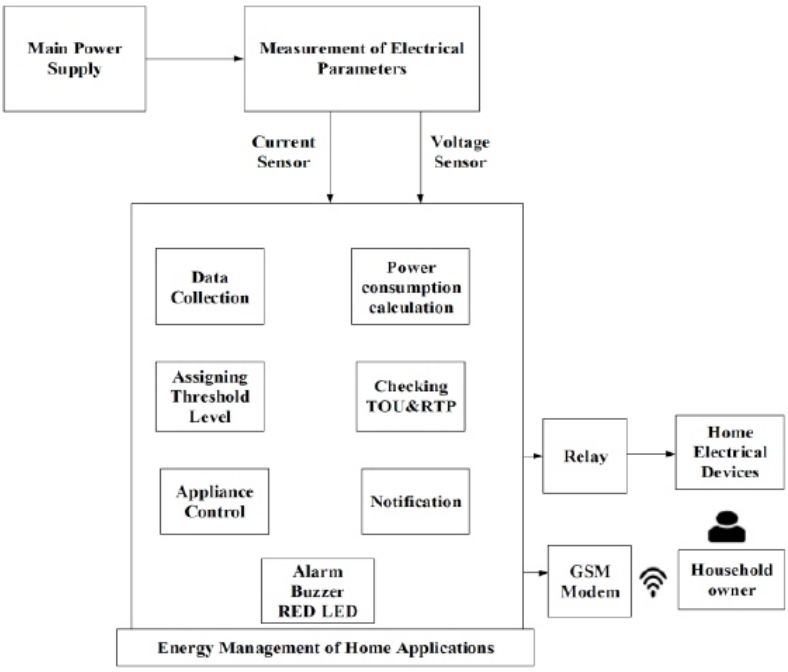

Figure :1 Block Diagram for Home Energy Management System

Figure [2] shows the flow chart of home energy management system. In this flow chart, firstly the EMS system collects the data and then calculates the amount of power consumption. And it assigns the threshold level unit and notify when over the amount the consumption unit. The household owner can desire the power consumption data of high loads at threshold level by sending SMS command (on/off) from microcontroller to GSM. GSM acts as the communication medium between controller and mobiles. If the household owner does not desire to close the appliance when he got the notify message, all loads are in the working condition.

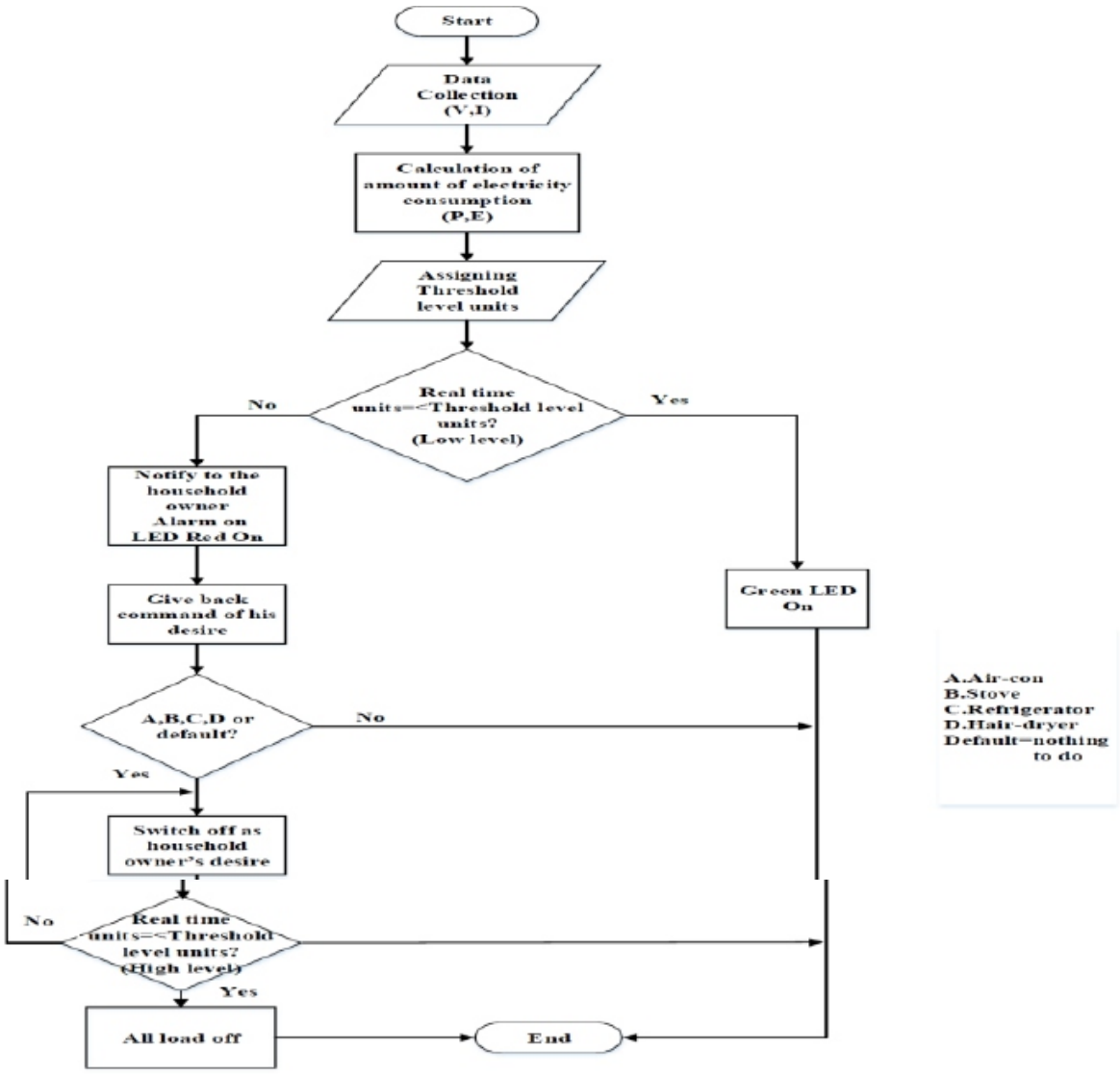

Figure:2 Flow chart of Home Energy Management System

B. Hardware components

Even the EMS is intended to use as a part of a smart home system, there is a little difficult in testing with real electric power line of 220 volts which is leading to an unsafe condition. Therefore, in order to overcome such kind of condition, the prototype of EMS system of a home in which single household owner is living is created for testing and evaluating the system. After validating our EMS system, it can be applied to a smart home. In this prototype, as high load appliances motor, iron, refrigerator, hair dryer, air-conditioner and washing machine are considered. And as low load appliances lighting, TV and laptop are considered.

As shown in the figure [3], in order to get the amount of power consumption of home appliances, current sensor (ACS712) and voltage sensor (ZMPT101B) are used. Arduino Uno is used as a heart of EMS system for energy management of home appliances. Real time clock is used for giving the information of date and time. The record of power consumption and the amount of power units are stored to the SD card data logger. If the meter units reach at threshold level units or over threshold unit, the appointed appliances will be off and notify to the household owner by using GSM modem. Moreover, the voltage, current and consumption unit are displaying on LCD.

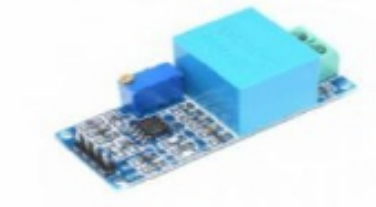

Fig. 3(a) ZMPT101B

Fig.3(b) ACS712

Fig. 3(c) Arduino Uno

Fig.3(d) GSM modem

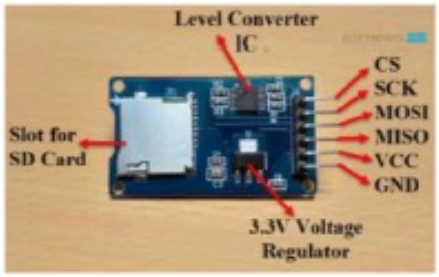

Fig.3(e) SD card

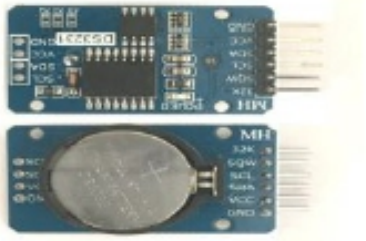

Fig. 3(f) RTC module

C. Circuit diagram

The LCD display shown in the figure (4) circuit diagram is used to monitor the load's voltage, current and meter unit level. Atmega328 microcontroller is used to control the whole system and Arduino IDE language is used for programming. The ACS712 current sensor is used to know the current flow of the home appliances. The ZMPT101B voltage sensor is used to calculate and monitor the amount of voltage in home appliances.

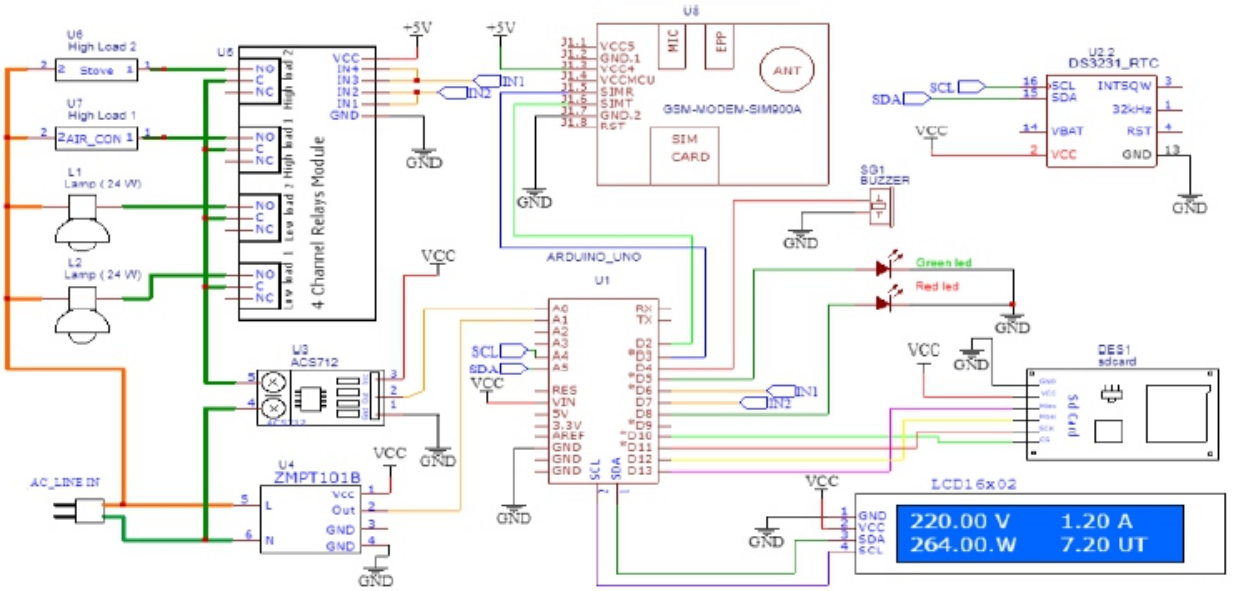

Figure:4 Circuit diagram of Home Energy Management System

III. ALGORITHM AND IMPLEMENTATION OF COST-EFFICIENT HEMS

Based on the above system requirements, the proposed system's algorithm and implementation of HEMS are as follows:

A. Electricity Pricing Mechanisms

There are two different electricity pricing mechanisms: specially time of use (TOU) and real time pricing(RTP). [8] TOU applies to usage over board blocks of hours where the price for each period is predetermined and constant. RTP is generally an hourly rate which is applied to usage on an hourly basis.

B. HEMS Algorithm

Firstly, it needs to assign two levels of threshold units of power consumption. Then by checking with those threshold units, the amount of power consumption can be controlled weekly by weekly. When the RTP unit is equal to the threshold level low unit, notify to the user by alarming with buzzer. The amount of consumption (low level threshold) unit is displayed on LCD. At that time the user can check not only to switch off the high loads but also switch on by using the EMS system. The message (HIGH loads off) is also displayed on LCD. According to High load off condition, the user, when the RTP unit is the greater than or equal to the threshold level high unit, notify to the user by alarming with buzzer and RED LED On. And then, GSM performs as the message in- between controller and mobiles. The amount of consumption (high level threshold) unit is displayed on LCD. Message (All loads off) is also displayed on LCD.

C. Assigning threshold level unit

The home appliances are shown in table 1 where the average consumption time have been used for calculation purposes as shown in table 2.

High Load		Low Load
Always	Sleep	Sleep
1.Refrigerator	1. Air-conditioner	1.Lighting
	2.Motor	2.Laptop
	3.Iron	3.TV
	4.Stove	
	5.WashingMachine	

Table 1: List of Loads for a Single-Use

The threshold level unit can be classified into two parts by High level and Low level unit. The threshold level unit can be take the home appliances which is expressed in table 1 by depending on the amount of average consumption for a day. It can be easily calculated to get consumption unit for a week or month by getting the amount of electricity consumption for a day.

Usage Time (Average)	Threshold Units (High)	Threshold Units (Low)
1 day	10	8
7 day	70	56
30 days	300	240

Table 2: Electricity consumption for usage time

D. Calculation for power consumption

By using equation no (1), the amount of power consumption(P) can be calculated by using energy(E) and usage time(t). P= E/t equation [1] If a 1000 watts Dryer burns for one hour, 1unit is used. Power consumption is calculated by using the equation [1]. P=1000W t=1 hour (for high load) E=P x t / 1000 = 1000 x 1/ 1000=1 unit If a 100 watts lighting burns for ten hours, 1unit is used. Power consumption is calculated by using the equation [1]. P=100W t=10 hour (for low load) E=P x t / 1000 = 100 x 10/ 1000=1 unit

E. Test and Result

The implemented system is tested practically with home appliances at real time and this prototype operates effectively with secure operation. According to the amount of electricity consumption of high load and low load during 1-hour calculation result, the threshold level unit is assigned with 1 unit of low level and 2 units of high level for a prototype. In figure 5(a), (b) and(c), if the meter unit reach the low threshold level unit, RED LED will be turned on. When the amount of electricity consumption has been used 1 unit, the household owner can turn on/off High loads. If the household owner wants to close the

High loads, the microcontroller will receive command(@a0) SMS from GSM. Otherwise, the household owner opens the High loads, the microcontroller will receive command (@a1) SMS from GSM.

5 (a)

5(b)

Figure:5(a) The amount of electricity consumption of load displayed on LCD and 5(b) Notification message of 1 unit usage and asking to household owner whether high loads to be off or not

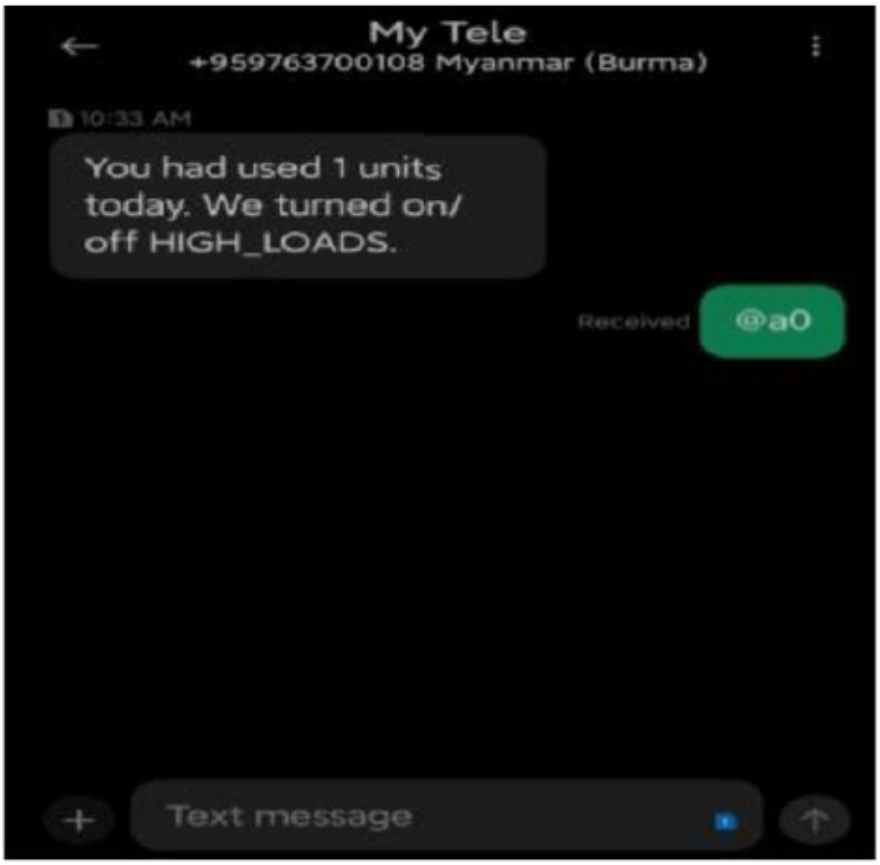

Figure: 5(c) Result of High load OFF(@a0) Command SMS on GSM

In figure 6(a), (b) and (c), after using the electricity consumption of 2 units, all the loads are off and display the voltage, current, power and unit on the LCD. If the over the threshold level units, alarm will on by using buzzer not only RED LED on but also all loads will off. And then, the notification sign to the household owner has been sent SMS by using the GSM modem. As using the GSM modem, the household owner can check the EMS system not only at home but also outside from anywhere.

Figure:6(a) The amount of electricity consumption of load displayed on LCD

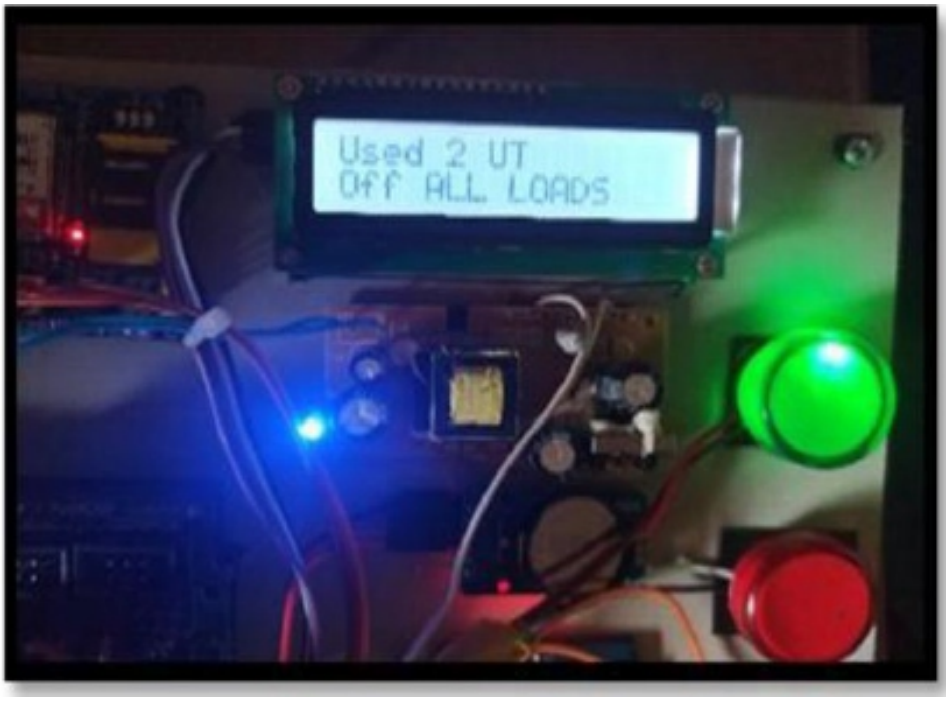

Figure:6(b) After using 2 units, all loads off displayed on LCD

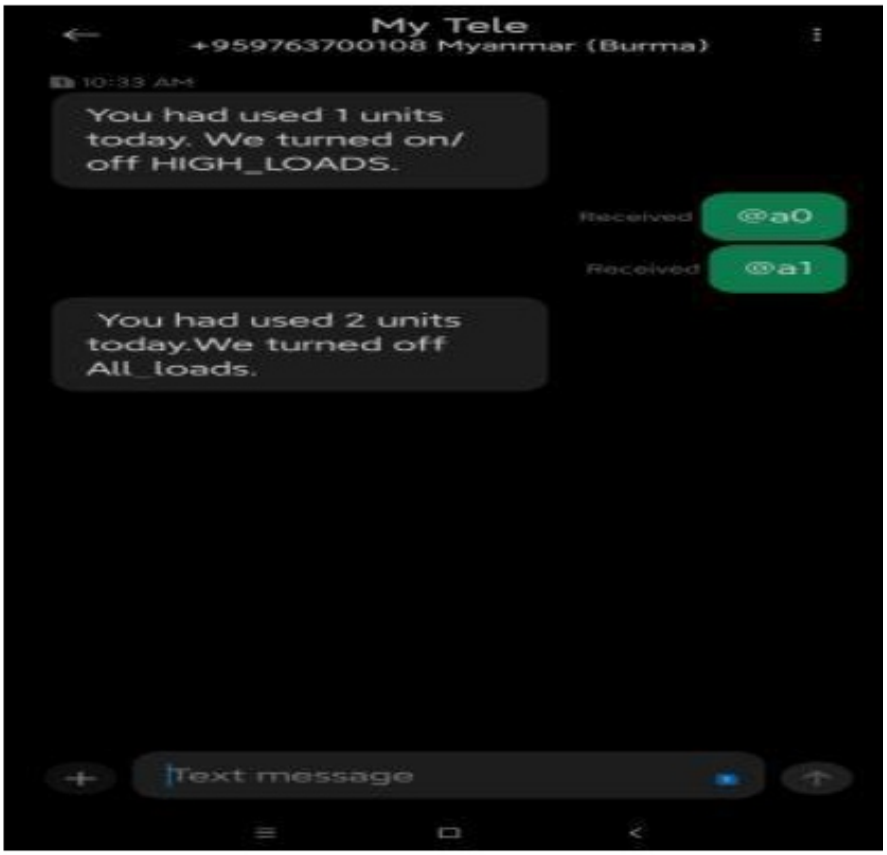

Figure: 6(c) 2 units usage of sms by using GSM modem

F. Data storage on SD card

The record of electricity consumption unit is stored to recheck by the type of chart and graph.

Time	Consumption Unit
12.00.00 PM	0
12:30:00 PM	1.01
1:00:00 PM	1.06
1:30:00 PM	1.12
2:00:00 PM	1.17
2:30:00 PM	1.21
3:00:00 PM	1.26
3:30:00 PM	1.31
4:00:00 PM	1.36
4:30:00 PM	1.41
5:00:00 PM	1.46
5:30:00 PM	1.51
6:00:00 PM	1.56
6:30:00 PM	1.61
7:00:00 PM	1.66
7:30:00 PM	1.71
8:00:00 PM	1.75
8:30:00 PM	1.8
9:00:00 PM	1.85
9:30:00 PM	1.9
10:00:00 PM	1.95
10:30:00 PM	2

(a)

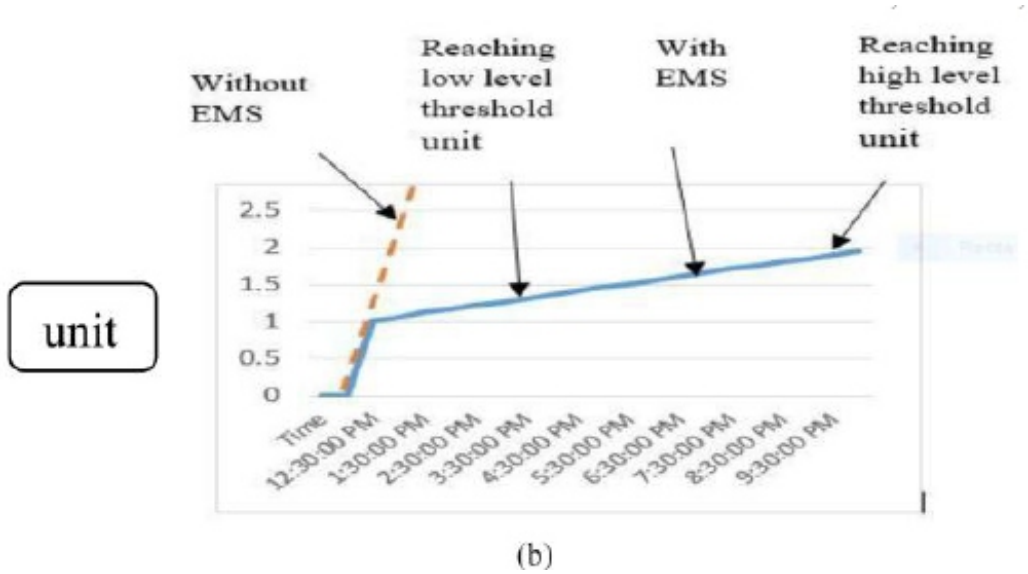

Figure: 7 (a) Chart and (b) graph of the electricity consumption of home appliances for a day by using Energy Management System

G. Evaluation

EMS system can provide easily the consumption unit of electricity by using unit conversion method. Figure 7(a) and (b) show the energy saving result of this system testing with the prototype for a day. Figure 7 shows the chart and graph of the electricity unit consuming by home appliances. For testing a day period, the owner starts the EMS system at 12 PM as the setting point of prototype during the 11-hours period, and it starts counting the consumption unit. When it reaches the threshold low level unit, the household owner can desire to turn high loads on or off. Between low and high levels of threshold units, only low load appliances are running. At the instant of reaching the high level, all low loads will be off automatically according to EMS.

As shown in Figure 7(b), it can be clearly seen the gap of two consumption amounts with and without EMS. The specific consumption is on the basis of real time working status of prototype. By using energy management system, the owner could control the home appliances, which could save lots of energy due to high loads are the most power–starved appliances in daily life.

The comparison of electricity consumption for usage time is shown in table (4), the average usage time for a day during 11- hours period with the amount of electricity consumption is calculated and for the case without EMS it is found to be 20 units. When EMS is used in the household, the electricity consumption has reduced to 10 units. Therefore, the saving of the electricity cost due to the operation of developed EMS is 50%.

Usage Time (Average)	Power Consumption unit without EMS	Power consumption unit with EMS	Power saving(%)
1 day (11hours)	20	10	50%
7 day	140	70	50%
30 days	600	300	50%

IV. CONCLUSION

The paper focus on the design and implementation of cost-efficient home energy management system. Home energy management system is for the control of amount of electricity unit and saving the energy. The use of EMS provides more information and control over the electricity consumed, to the household owner. The developed system can be implemented on any home appliances and the whole home can be handled with a HEMS.

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