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Microscopic Digital Image Segmentation And feature Extraction of Acute Leukemia

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***Abstract*—** The goal of this paper is to identify and show the differences in the properties of Acute lymphoblastic leukemia (ALL) and normal white blood cells. This paper was conducted on a set of microscopic digital images of blood samples that got it from the "Oncology Center - Faculty of Medicine - Mansoura University Hospital - Egypt" is made up of 50 microscope image samples of Cancerous blood and 50 microscope image of the blood samples is not Cancerous (normal blood). The microscope blood images are undergo to chain of pre-processing steps which include resizing image such as (512*512, 256*256, 128*128) and contrast enhancement. By executing K-means clustering on the resultant images, the cell's nucleus under consideration is obtained then these segmented images enter sub-image stage. The next step is Extracted Features that included: Shape features (Area, *Perimeter, Compactness, Solidity, Eccentricity, and Elongation*); texture features (*Homogeneity, Energy, Correlation, Entropy, and Contrast*); color features and Fractal Dimension.

***Keywords* —** *(Digital Image Processing , Acute Leukemia , Normal White Blood Cell ,Contrast Enhancement , K-Means Clustering , Features Extraction)*

I. INTRODUCTION

Acute lymphoblastic leukemia (ALL), also known as acute lymphocytic leukemia, or acute lymphoid leukemia, is an acute form of leukemia, or cancer of the white blood cells, distinguished by the overproduction and cumulation of cancerous, immature white blood cells, known as lymphoblasts [1]. Leukemia is "a cancer of the blood cells (WBC). It starts in the bone marrow when abnormal cells (infected WBC) redouble out of control To the extent that normal blood cells (uninfected WBC) are incapable to develop". Which usually affects blood, bone marrow, and lymph nodes. It is distinguished by proliferation of abnormal white blood cells (leukocytes) in the bone marrow without responding to cell outgrowth inhibitors [2]. Four Most Common Kinds of Leukemia:

1. **Acute myeloid leukemia (AML)** influence myeloid cells and grows rapidly. Leukemic blasts cells gather in the bone marrow and blood. About 15,000 Americans was diagnosed with AML in 2013. Most (about 8,000) was 65 or older, and about 870 children and teens will infect this disease.

2. **Acute lymphoblastic leukemia (ALL)** affects lymphoid cells and grows rapidly. Leukemic blast cells usually collect in the blood and bone marrow. More than 6,000 Americans was diagnosed with ALL in 2013. Most of them (more than 3,600) were children and teens.

3. **Chronic myeloid leukemia (CML)** influences in myeloid cells and typically grows slowly at first. Blood tests show a rise in the number of white blood cells. The abnormal blood cells work okay. May be there are a small number of leukemic blast cells in the bone marrow Nearly 6,000 Americans was diagnosed with CML in 2013. Nearly half (about 2,900) were 65 or older and only Nearly 170 children and teens will infect this disease.

4. **Chronic lymphocytic leukemia (CLL)** influences in lymphoid cells and usually grows rapidly. Blood tests show a rise in the number of the white blood cells. The actin of the abnormal cells nearly as well as the normal white blood cells [3], [4], Figure (1) shows the Kinds of Leukemia.

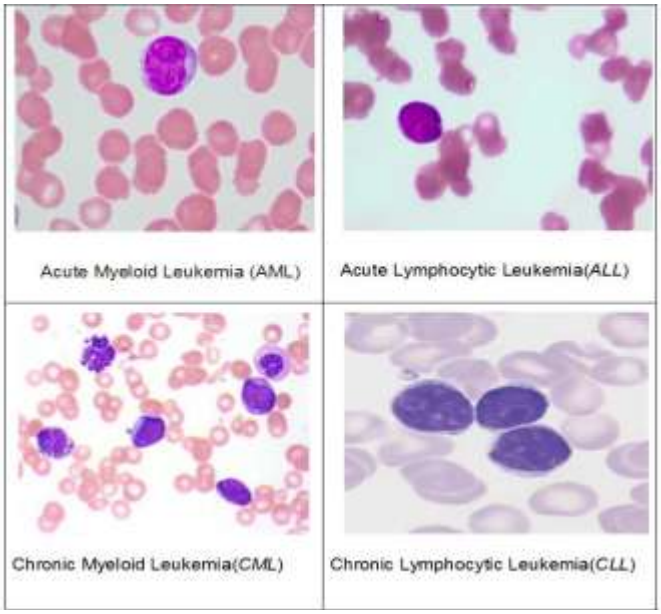


Figure (1) Kinds of Leukemia

Figure (2) and Figure (3) how the difference between normal (Non-Cancerous) blood smear and abnormal (Cancerous) blood smear the one affected with Acute Leukemia.

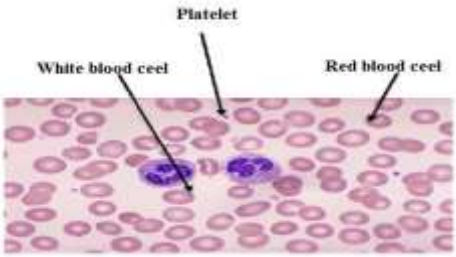


Figure (2) Non-Cancerous Blood Smear (Normal)

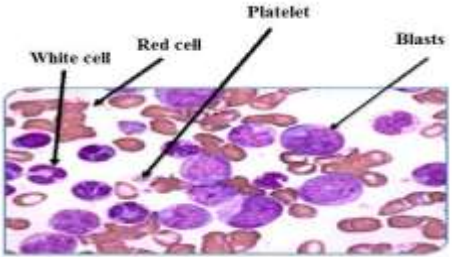


Figure (3) Cancerous Blood Smear (Abnormal)

II. DIGITAL IMAGE PROCESSING (METHODS)

The procedure of Segmentation and Features extraction for Acute lymphoblastic leukemia (ALL) in microscopic blood images consists of pre-processing (resize and contrast image), segmentation using (k-means clustering), feature extraction (shape – texture – color – HD) .The proposed system is shown in Fig. (4).

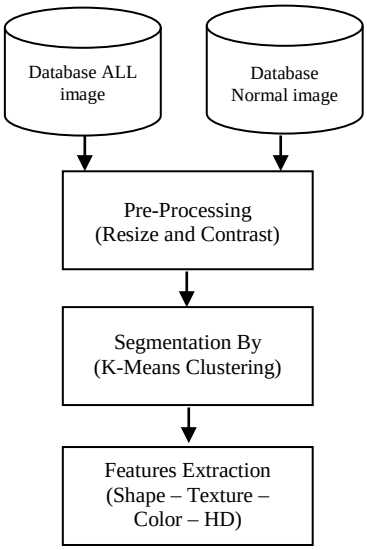


Fig.(4). System Overview

A. *Pre-processing*

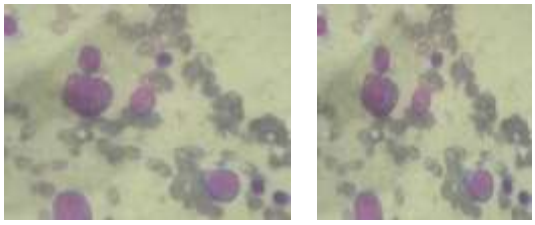
Pre-processing methods can be splitted into the two groups according to the goal of the processing:

First: - Image resizing such as 512*512, 256*256 and 128 * 128.

Second: - Contrast enhancement by employ the "*fspecial*" function with the "*unsharp masking*" filter has the effectiveness of making edges and fine detail in the image more crisp [5], then apply this mask filter on image by using "imfilter" function with Boundary Option "replicate" that Input array values outside the bounds of the array are assumed to equal the nearest array border value [6].

Algorithm: Pre-processing using unsharp (Filtering)

- Read input image (X).
- Use Y = imresize (X, [512*512]).
- Create new variable color filtered for having same attribute that of input image using unsharp masking filter.
- Apply boundary option replicate filter algorithm on s Merge all three planes together eparated RGB planes.
- Merge all three planes together.
- Output (Y) shown in Fig. (5).



(X) Input Image (Y) Resize 512*512 & Contrast Image

Fig. (5)

B. *Segmentation*

Segmentation is executed in two stages for extracting WBC nucleus from the blood microscopic images using color based clustering. Initial segmentation are completed by K-means clustering followed by nearest neighbor classification in L*a*b* space. K-means is a semi supervised clustering technique which is employ to create K clusters from n observations. It is aiming to achieve partition such that objects within each cluster are as near to each other as possible, and as far from object in the other clusters as possible [7]. Each pixel of an object is classified into four clusters based on corresponding a* and b* values in L*a*b* color space as shown in Fig. (6). This four clusters represents four regions i.e. RBC, WBC nucleus, cytoplasm and background stain. It was observed that WBC cytoplasm and RBC are classified into same cluster. In order to overcome the undesirable overlapping of regions, a second stage segmentation is performed using nearest neighbor classification. In the second stage we choose a

sample region randomly from each of the four clusters acquired using K–means. The mean color of the each sample regions are calculated in a*b* space and those values act as color indicators. here each pixel in the L*a*b* space is distributing into any of the four classes by computing the Euclidean distance between that pixel and each color index. Each pixel of the whole image will be labeled to a specific color depending on the minimum distance from each index. The nucleus segmented RGB image is reconstructed from the labeled image. We have only considered the cluster which contains blue nucleus as it is required for feature extraction and hence leukemia detection. Few left out holes in the nucleus creates problem during texture extraction and hence they are filled using morphological reconstruction [8].

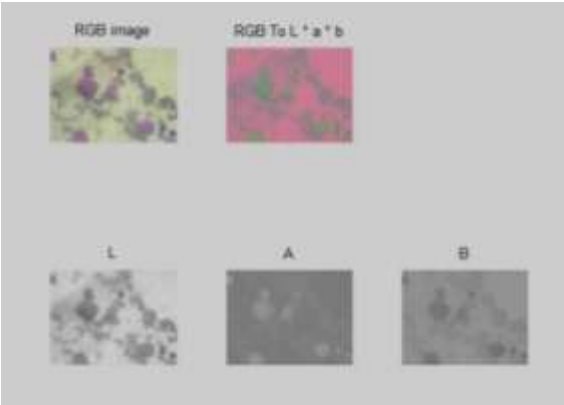
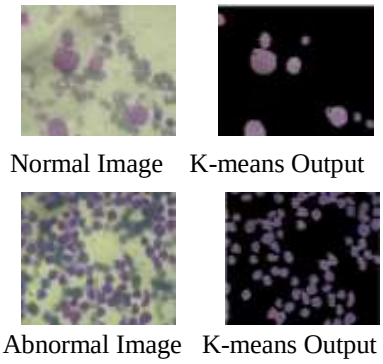


Fig. (6)

Algorithm Segmentation using K-means clustering

- Read Enhancement image (Y).
- [l a b] = Convert To L*A*B space
- A_B = Merge A*B space
- [r c] = get size (A_B)
- A_B_new = reshape(A_B, r*c , 2)
- Apply K-means clustering and output as shown in Fig. (7).



Normal Image K-means Output

Abnormal Image K-means Output

Fig. (7)

C. *Sub Imaging*

Sub images including single nucleus per sub image are obtained using bounding box technique [9]. Using image morphology [10] only those sub images are selected which contains only lymphocytes. The nucleus sub images of neutrophils, eosinophil's, and basophils are not considered for feature extraction as they are not associated with lymphocytic leukemia.

Fig. (8). shows the major steps and examples of input/output images:

Step one) Input Image

Step tow) Sobel edge enhancing: - It's enhances the borders of the membranes [11].

Step three) Structured image dilation: - The morphological operator named dilation [12] has been employed to better connect to the separated points of the membrane border and make the perimeter of cell as a connected item (thicker more than one pixel).

Step four) Hole filling: -This step include of filling internal holes of the connected element with the largest area in the processed image [13, 14].

Fig. (9) shows separated Nucleus Sub Images using Bounding box technique.

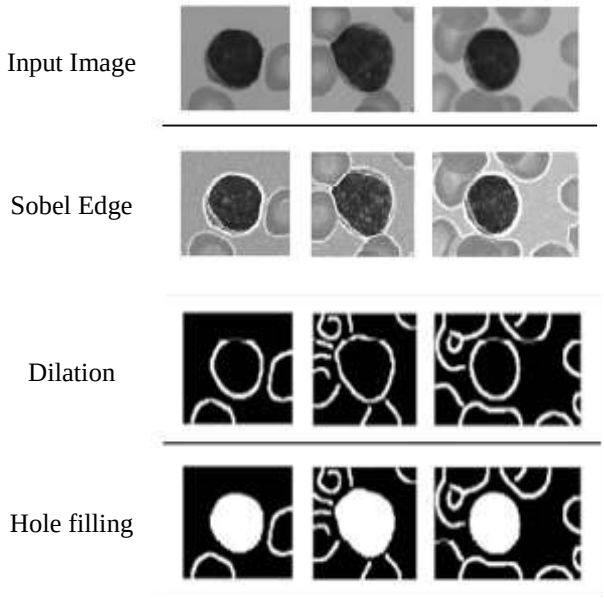


Fig. (8)

Fig. (9). Separeted Nucleus Sub Images using Bounding box technique

D. *Feature Extraction*:

Feature extraction in image processing involves reducing the amount of resources required to describe a large set of data. In the present paper broadly four types of features are extracted (shape features, texture features, fractal dimension. In addition also color features are extracted from the nucleus image).

A: Shape Feature:- According to the hematologist the shape of the nucleus is an essential feature for distinguish of blasts. boundary based shape features and Region are extracted for shape analysis of the nucleus. All the features are extracted from the binary equivalent image of nucleus with nonzero pixels represents the nucleus region. For each nucleus we make a quantitative evaluation by using the extracted features under two classes. Region based and boundary based. These features are as follows:

- *Area:* It was determined by computation the total number of nonezero pixels within the image region.
- *Perimeter:* the perimeter was measured by computation distance between the successive boundary pixels.
- *Compactness:* Compactness or roundedness is the measure of a nucleus as defined in (1).

$$Compactness = \frac{Perimeter^2}{Area} \quad (1)$$

- *Solidity:* The solidity is the ratio of actual area and the convex hull area and is also an essential feature for classification a blast cell. This measure is defined in (2).

$$Solidity = \frac{Area}{ConvexArea} \quad (2)$$

- *Eccentricity:* This parameter is used to measure how much a shape of a nucleus deviates from being circular. It's an important feature since lymphocytes are more circular than the blast. To measure this a relation is defined in (3).

$$Eccentricity = \frac{\sqrt{a^2 - b^2}}{a} \quad (3)$$

where "a" is the major axis and "b" is the minor axis of the equivalent ellipse representing the nucleus region.

- *Elongation:* Abnormal bulging of the nucleus It's also an feature which indicates towards leukemia. Hence the nucleus bulging is measured in terms of a ratio called elongation. This is defined as the ratio between maximum distance (R_{max}) and minimum distance (R_{min}) from the center of gravity to the nucleus boundary and is given by (4).

$$Elongation = \frac{R_{max}}{R_{min}} \quad (4)$$

Where R_{max} and R_{min} are maximum and minimum radii respectively.

- *Formfactor:* This is a dimensionless parameter which changes with surface irregularities and is defined as (5).

$$Formfactor = \frac{4 * pi * Area}{Perimeter^2} \quad (5)$$

B: Texture Feature-:The nucleus texture measurements were performed on a gray scale version of the nucleus images. These features were computed from the co-occurence matrices for each nucleus image. This includes:

- *Homogeneity*: It is a measure of degree of variation.
- *Energy*: The energy are used to measure uniformity.
- *Correlation*: This represents the correlation between the pixel values and its neighborhood.
- *Entropy*: It is usually used to measure the randomness.
- *Contrast:* The contrast is a measure of the intensity contrast between a pixel and its neighbor over the entire image.

C: Color Feature:- Since color is an important feature that human perceiv ewhile visualizing it is considered for extraction from nucleu sregions. Hence for each nucleus image the mean color values in RGB color spaces are obtained. [15].

D: Fractal Dimension:- Fractals have been used in medicine and science previously for several quantitative measurement [16] [17]. the important measure that decided whether a particular nucleus represents a lymphoblast or a mature lymphocyte is the Perimeter roughness of nucleus. the more convenient way to parameterize the cell boundary surface in comparison to Euclidean geometry is fractal geometry. Hausdorff dimension (HD) is a main feature for fractal geometry and will be a main quantitative measure for cell boundary roughness measurement. a procedure for Hausdorff Dimension (HD) measurement using box counting method [18]. The Hausdorff Dimension *HD* may then be obtaned as in (6).

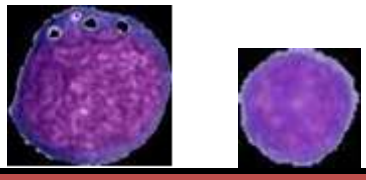
$$HD = \frac{Log(N)}{Log(N(s))} \quad (6)$$

where, N the number of squares in the superimposed grid, and N(s) the number of occupied squares or boxes (box count). Higher HD denote to higher degree of roughness.

Table 1 displays the difference in the values of the shape features for a pair of cancerous and noncancerous (normal)

cell. Values indicate steep difference among the two sub-images.

Table 1 Shape Feature Values



Features	Cancerous 7	Normal 42
Area	2089.5	1056
Perimeter	407.79	280.98
Compactness	80.26	74.76
Convex Area	6175	2137
Solidity	0.657	0.494
Eccentricity	0.442	0.439
Elongation	123.06	100
Form Factor	64.35	47.20
Contrast	0.668	1.362
Correlation	0.756	0.634
Homomgeneity	0.839	0.810
Energy	0.159	0.192
Entropy	2.237	2.069
Mean	221.26	35.21
Standard Deviation	750.99	128.99
HausDroff	1.934	1.808

III. EXPERIMENTAL RESULT

The proposed technique has been applied on 100 blood smear images obtained from "Oncology Center - Faculty of Medicine - Mansoura University Hospital - Egypt" is made up of 50 microscope image samples of blood infected , 50 microscope image of the blood samples is not infected.

A. Experiment

The experiment work of proposed system consist several steps, all image are preprocessed by MATLAB to contrast enhancement and resize be defined as in Table I. The system segments all dataset image (cancer and normal image) ,and we get separated nucleus sub Images using Bounding box technique to extract all features.

B. Result Analysis

The experimental result has been developed by taking the sub-images. The entire test images are gone through the Preprocessing – Segmentation and from the sub-images obtain Features Extraction.

Table.2

Pre-processing (contrast – resize)	Time	
	Cancer 45 image	*Normal 45 image*
512*512	14.7313	14.778
256*256	13.412	13.7233
128*128	12.8222	12.2991
600*400	14.9824	145964
300*200	13.2879	13.1211
200*180	12.8286	12.8089

Table.3

Segmentation K-Means	Time	
	Cancer 45 image	*Normal 45 image*
512*512	54.4611	52.575
256*256	14.5826	14.9145
128*128	8.1589	6.2723
600*400	49.5682	48.9681
300*200	13.5127	13.5717
200*180	12.5690	12.3620

Table.4

Sub – Image	Time	
	Cancer 45 image	*Normal 45 image*
512*512	9.47817	10.1307
256*256	3.8499	3.67331
128*128	3.42657	2.94794
600*400	7.92125	7.48196
300*200	3.88147	3.99509
200*180	3.7890	3.6025

Table.5

Features Extraction	Time	
	Cancer 45 image	*Normal 45 image*
512*512	16.898	17.0685
256*256	5.21939	5.31412
128*128	2.42911	2.84163
600*400	29.3403	29.1306
300*200	8.20683	8.09558
200*180	3.6898	3.45067

IV. CONCLUSION

This paper has present segmentation (K-means Clustering) technique and features extraction (Shape – Texture – Color – HD) and BP – SCG neural network for classify. The system was evaluated in MATLAB 2014 and using data base 50 infected images and 50 non – infected images. The system is less computational requirement this make system well suited for low cost hardware implementation.

V. ACKNOWLEDGMENTS

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Optimizing Properties of Sandcrete Blocks Produced In the Warm-Humid Climatic Zone Of Nigeria

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ABSTRACT

In the Nigeria construction industry, non compliance to existing standards has been one of the major causes of substandard material production and to an extent poor housing development. It has therefore degenerated to the inability of dictating standards with the performances of building materials in the industry. The threat of this ugly situation grows higher when materials of composite natures are involved. In this era of innovation in the construction technology generally, the study focuses on providing a more reliable and faster mean to producing sancrete blocks of desired properties starting with Warm Humid Climatic (WHC) zone of Nigeria. In the beginning, field survey method was adopted to obtain information on the apriori knowledge of the common nominal mix ratio used in producing sandcrete blocks in the area. The information was used as a basis for designing the sandcrete mixes using Box-Wilson symmetric Composite Plan B_m. Laboratory experimental tests were carried out on the blocks produced with the various mix designs to obtain values on their density and compressive strength properties. Polynomial regression models were therefore developed, and subsequently tested to certify their fitness considering only the independent variables (cement, water, and sand aggregates) that are significant for the respective properties. Mono-factorial effects of the variables were investigated on the properties to ascertain the degree of their influences on the respective properties. Progressively, optimal equations of the final regression models were therefore developed having optimized the respective significant variables in the models, using the quadratic equation for blocks of optimum and desired performances. To this end, nomograms were therefore constructed with the optimal values derived from the optimal equations to reflect various optimum compositions of the constituent ingredients (variables) for certain desired properties of the blocks, depending on the functional requirements or purposes of use. In the light of this rare development, speedy decisions productions of the blocks of desired properties will be possible and accurate. Production of the targeted properties of the blocks would therefore, not be hindered by the limited quantity of any of the ingredients, since there are possibilities of other optimum compositions that would accommodate the limitation in quantity of the said ingredient.

Key Words: Sandcrete Blocks, Mix Designs, Box-Wilson Symmetric Composite Plan B_m, Nomograms, Optimum Compositions, and Desired Properties

INTRODUCTION

Building construction materials are various substances or item that form the basic component of various element of a building. From the beginning to the end of the building construction process, materials that are primarily used on site are cement, sand aggregates, water, steel, and timber. These are referred to as star materials (Ikechukwu, 2012). Most of them are naturally occurring, some are artificially processed while others are usually mixed together to give different components and elements found in erection of any building structure. Although the constituent ingredients found in the composite materials satisfy some set standard, the ratio of their compositions to one another is a notable factor that influences the quality of composite construction materials like, sandcrete blocks. The composition of the constituent ingredients of the blocks produced in WHC of Nigeria influences to a great extent the choice and quality of sancrete blocks used in the area. Each of the three major ingredients (cement, water and sand) of sandcrete block has factorial effects on the major properties of the block (Ikechukwu, 2015); giving the reason any one of them could be optimized in the mix for optimal values of the properties respectively, within the boundary limits of the design.

A nominal (conventional) mix ratio of the block does not take into account the mono-factorial effects of the respective ingredients in a certain locality (Okereke, 2002). The mix therefore, could not be optimized for improved performance of the component for lack of appropriate basis hence; the production of the desired quality may not be feasible in the end. Even though the use of nominal mix ratio has been a measure in the quality control process, it leaves no room for desired properties let alone the possibility of various optimum compositions of the constituent ingredients for the same desired property.

METHOD OF EXPERIMENT AND ANALYSIS

Designed experimental method was adopted to clearly study empirically the role of the various factors on the quality of sandcrete blocks produced in Owerri Metropolis as a representative of the warm humid climatic zone of Nigeria for the purpose of construction works. Results from these experiments were meant to pave way for establishing appropriate standards for sandcrete block production in the area. For this purpose, data from the designed experiments were transformed into regression models.

The regression models were obtained, and according to Okereke (1991) and Raissi (2009), it involves the following stages:

i. **Obtaining Regression Models**: Two Regression models of the second degree for each of the parameters of interest (density, and strength) at the 28-day age are obtained in the form:

$$y_i = b_0 + b_1x_1 + b_2x_2 + \ldots + b_nx_n + b_{12}x_1x_2 + \ldots + b_{ij}x_{ij} + b_{11}x_1^2 + b_{22}x_2^2 + \ldots + b_{ii}x_i^2 \quad \textbf{.....(1)}$$

or

$$y_i = b_0 + b_i\sum X_i + b_{ij}\sum x_ix_j + b_{ii}\sum x_i^2 \quad \textbf{.....(2)}$$

Where, b_i are the regression coefficient and x_i – the independent variables (I = 1, 2 and 3).

ii. **Carrying out Regression Analysis** – This is the stage of checking for adequacy (fitness) of the models using the Fisher statistics with the criteria, $F_{cal} \leq F_t$ for adequacy (fitness).

iii. **Carrying out Factorial Analysis** – Investigating the effects of the variables x_i as well as their mutual effects – x_ix_j. For this purpose, a quasi-mono factorial analysis is carried for each of the dependent variables (factors), at coded values of +1 and – 1.

iv. **Carrying out Optimization Analysis** – This is the process of searching for optimal values at which the parameters will assume the desired (optimal) values. According to Okereke (2004), these optimal values were used in the construction of nomograms. It is a graphic method for speedy determination of the respective quantities of the ingredients of the sandcrete mix for a given value of any of the parameters (objective functions), such as compressive strength and density properties. A total of 2 regression models for the strenght and density properties of the sandcrete mixes were obtained at the 28-day curing age, respectively. These models for the blocks in the experiments are presented in the following forms, respectively.

Regression Models for the Properties of Sandcrete Blocks Manually Produced in the WHC

i. For Mixes on Compressive Strength Property

$$R_{D28(hs)} = b_0 + b_1x_1 + b_2x_2 + b_{11}x_1^2 + b_{12}x_1x_2$$

$$= 1.975 + 0.085x_1 + 0.054x_2 + 0.062x_1^2 + 0.034x_1x_2 \quad \ldots\ldots\textbf{(3)}$$

ii. For Mixes on Density Property:

$$\rho_{hs28} = b_0 + b_1x_1 + b_2x_2 + b_{22}x_2^2 + b_{33}x_3^2$$

$$= 1926 + 6.20x_1 + 14.40x_2 - 6.78x_2^2 - 5.28x_3^2 \quad \ldots\ldots\textbf{(4)}$$

Factorial Analysis of Eqs. (1 and 2)

Compressive Strenght

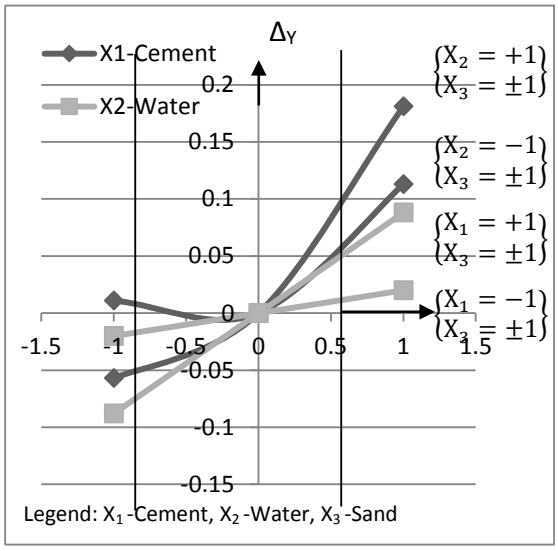

Fig. 1

Combined Effect of X_1 and X_2 on the Strenght ($R_{28(hs)}$)

Density

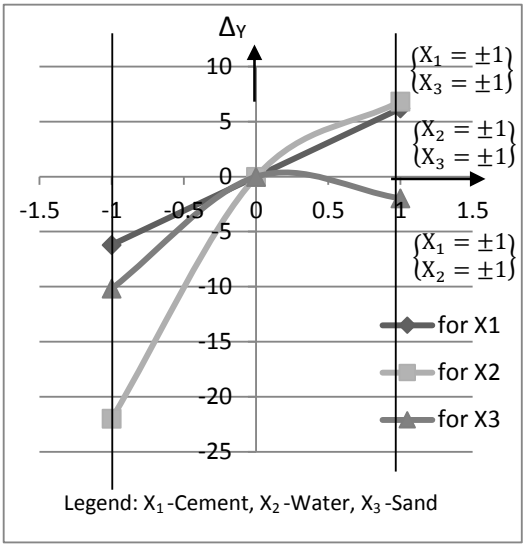

Fig. 2

Combined Effect of X_1, X_2 and X_3 on Density ($\rho_{28(hs)}$)

Optimization of the Composition of the Sandcrete Mix Produced Manually

Optimal values of the composition (ingredients) of the mix were used to substitute the compromised values of the significant variable (x_1 and x_2) in the derived models (Eqs. 3 and 4). As in Veh-matti (2011); polynomial equations were obtained as optimal equations of the model in Eqs.3 and 4 respectively. The optimal equations (Y_{opt}) derived are as shown in Eq. (5) and (6) below.

$$R_{28(hs)}(opt) = 1.97 + 0.11x_1 - 0.004x_2 - 0.004x_1x_2 = 0.005x_2^2 \quad \ldots \quad \textbf{(5)}$$

$$\rho_{28(hs)}(opt) = 1903.25 + 3.47x_2 + 3.39x_3 + 0.58x_2x_3 \quad \ldots \quad \textbf{(6)}$$

Nomograms were therefore constructed from Eq. (5) and (6) by substituting the optimal values of the independent variables (x_1, x_2 and x_3) in the respective equations. The nomograms for the desired compressive strength and density properties in the WHC are shown in Fig. (5) and (6) respectively.

Compressive Strenght (N/mm^2)

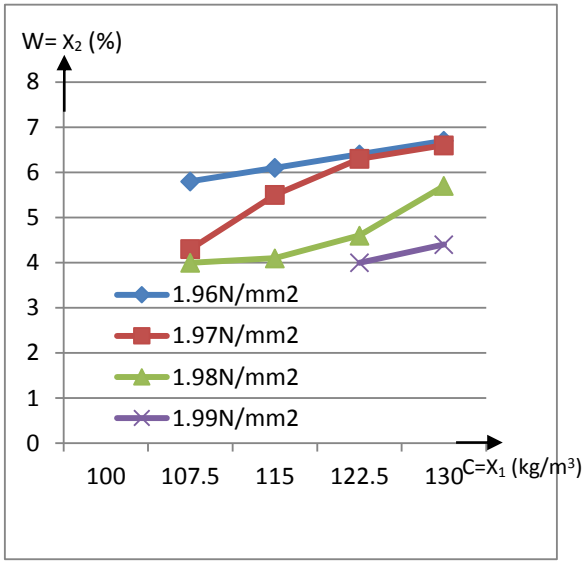

Fig. 3:

Density (Kg/m^3)

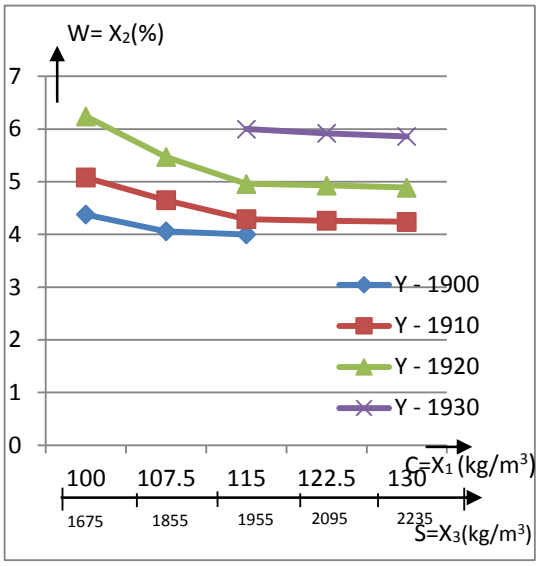

Fig. 4:

Nomograms for Manually Produced Sandcrete Blocks with range (1.96 - 1.99 N/mm^2) for Compressive Strenght (Fig. 3) and with range (1900 - 1930 Kg/m^3) for Density (Fig. 4), respectively.

With these nomograms, it is possible to produce sandcrete blocks using hand mould to obtain the desired compressive strength with a range of 1.96 to 1.99 N/mm^2, and the desired density of 1900 to 1930 kg/m^3, with corresponding cement, water and sand contents in the WHC respectively, (Fig. 3 and 4).

SUMMARY OF FINDINGS

Regression analysis based on the Box-wilson symmetric composite plan B_3 (Box et al, 1951), was used to establish the relationships between each set of the mix designs and the properties (objective functions). This approach is not only cost effective, because of the few number of experimental points used, but also resulted in fundamental experimental data which were used to develop multi-factorial regression models, validated with appropriate regression analyses for each of the models .

These optimized mixes, with their corresponding optimal compositions were presented diagrammatically in the form of Nomograms in the study. The Nomograms serve as guides in designing sandcrete blocks with the desired level of the respective properties, as well as forming standard for quality control of suitable sandcrete blocks produced in the WHC zone of Nigeria thus, laying the foundation for establishing appropriate standards for quality control regulation of this common but important building material.

Through this feat, the following ranges of compressive strength and density properties are ($1.96 \leq R_{28} \leq 1.99/mm^2$), and ($1900 \leq \rho_{28} \leq 1930kg/m^3$) respectively, for speedy determination of the mix compositions of the sandcrete blocks.

Examples of mix designs using the density nomogram are given below.

The mix composition for desired density of $1900kg/m^3$ in the study can be obtained with some optimum composition as follows (Fig 4):

Cement (x_1) = 100 kg/m^3, Water (x_2) = 4.38%

Cement (x_1) = 107.5kg/m^3, Water (x_2) = 4.06%

Cement (x_1) = 115 kg/m^3, Water (x_2) = 4.00%

CONCLUSION

The notable achievements of this study is the optimization of sandcrete mixes, using the established optimal values from the optimization analysis of the regression models of the studied properties of sandcrete blocks when produced in the warm humid climatic zone of Nigeria.

Through optimization of sandcrete mixes, it has become feasible to produce blocks with pre-determined properties, with known quantities of materials to be used. The factorial analysis on the constituent ingredients (independent variables) in the study has therefore, proven the fact that the composition of various levels of the respective ingredient is a significant factor in influencing the quality of the sandcrete block. The benefit derivable from this is that prospective builders can order blocks with known properties, once they can afford to pay the cost. It will no longer be a matter of buying blocks which quality is a suspect or unknown.

With the developed nomograms, it is possible to speedily design sandcrete mixes that will be used to produce blocks that will have any desired properties such as strength and density, in any part of the WHC. They serve as guides in designing sandcrete blocks with the desired level of the respective properties, as well as forming standard for quality control of suitable sandcrete blocks produced in the area. This would therefore, lay the foundation for establishing appropriate standards for quality control regulation of this common but important building material in Nigeria.

The findings made in this study therefore, are very significant in the construction industry especially in the building sub-sector. They would opened up a vista of hope for the development of appropriate standards for some construction materials in Nigerian building sub-sector, where realistic standards appropriate to peculiar environments are lacking.

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The DC-fault Blocking Capability by a New Hybrid Multi-level Converter in HVDC Transmission

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Abstract: This paper explains the working principles, supported by simulation results, of a new converter topology in-tended for HVDC application, called the Alternate Arm Con-verter (AAC). Modular Multilevel Converters deliver small footprints and efficiencies above 99% in their half-bridge format, but only deliver DC-fault blocking with full-bridge sub-modules, and with an unacceptable penalty in efficiency. The Alternate Arm Converter (AAC) is a hybrid circuit topology using a mixture of full-bridge sub-modules and director switches which is capable of current control through DC faults while maintaining good efficiency in normal operation. It is hybrid between the modular multi-level converter, because of the presence of H-bridge cells, and the 2-level converter, in the form of director switches in each arm. This converter is able to generate a multi-level AC voltage and, since its stacks of cells consist of H-bridge cells instead of half-bridge cells, they are able to generate higher AC voltage than the DC terminal voltage. This allows the AAC to operate at an optimal point, called the "sweet spot", where the AC and DC energy flows equal. The director switches in the AAC are responsible for alternating the conduction period of each arm, leading to a significant reduction in the number of cells in the stacks. Furthermore, the AAC can keep control of the current in the phase reactor even in case of a DC-side fault and support the AC grid, through a STATCOM mode. Simulation results and loss calculations are presented in this paper in order to support the claimed features of the AAC.

Keywords: AC-DC power converters, emerging topolo-gies, fault tolerance, HVDC transmission, multi-level converters, power system faults, STATCOM

1. INTRODUCTION

Increasing attention is being paid to HVDC transmission systems, especially because most of the new schemes are intended to connect remote renewable sources to the grid and the most effective way to do it is to transmit the gener-ated power using HVDC instead of HVAC. For offshore HVDC applications, Voltage Source Converters (VSC) are more suitable than Current Source Converter (CSC) , thanks to their black-start capability and ability to operate in weak AC grids, such as a network of wind turbine generators. However, compared to CSC, their power ratings are limited and their efficiency somewhat poorer although recent developments in semi-conductor devices are closing the gap in both cases such that VSCs are becoming economically viable as technological solutions in large HVDC schemes; some of them, to be commissioned in the next couple of years.

The Alternate Arm Converter (AAC) is a hybrid voltage source converter topology which combines the IGBT switches (here called the director switches) of a 2-level converter with stacks of Sub-Modules (SMs) similar to those of the Modular Multilevel Converter (MMC) . The circuit diagram of an AAC is shown in Fig. 1. It has been demonstrated through simulations in that the AAC exhibits a high power efficiency (>99%)
and is able to retain control of the AC side currents during DC-side faults. This is in contrast to the half-bridge MMC, which contains an uncontrolled current path through the anti-parallel diodes in its SMs in the event of a DC-side fault.

The director switches are composed of series connected IGBT modules operating together at the fundamental frequency and directing the AC current toward either the top arm or the bottom arm. The stacks of SMs work in conjunction with their respective director switch and shape the converter voltage into a multilevel staircase voltage waveform, thus ensuring low distortion and minimising the required switching frequency of the semiconductor devices. Twice per AC cycle, both the upper and lower director switches within an arm are closed and in simultaneous conduction for a short period of time. This is referred to as the overlap period. This overlap period can be used to circulate balancing currents between the upper and lower arms of each phase, allowing for the energy stored with the SMs to be controlled. Arm current based control allows zero-current turnoff of the director switches. Previous iterations of the AAC have utilised an overlap in the region of 10 degrees. In this mode of operation the AC current is directly rectified into a DC current waveform that contains a six-pulse ripple. For this reason, a passive DC filter may be required in the form of a large DC inductor and bus capacitor, the size of which can be significant. The AAC in this mode has an operating point where the DC and AC side energies can be perfectly balanced, referred to as the sweet-spot. Operation away from this sweet-spot point is possible by consistently running controlled currents through the converter during

each overlap period. When at the sweet-spot, the AC voltage peak is 27% higher than the DC voltage. This means full-bridge capacitor SMs are required to allow the converter to over-modulate its output voltage. The full-bridge SMs allow the converter to operate under many degraded network conditions including DC faults. In it is further explained that the AAC can operate in different modes during a DC-side fault and provide some levels of reactive power by turning the AAC into a STATCOM converter. A new operational mode of the AAC, aimed at addressing several of the shortcomings of the previous design has recently been proposed . In this new operational mode, an extended overlap (EO) period of 60 degrees is used. This ensures a continuous conduction path for the DC current, allowing a smooth DC current waveform to be achieved. The EO mode of operation also allows the DC and AC side powers to be decoupled, resulting in an elimination of the sweetspot energy relationship between the AC and DC side voltage magnitudes.

Increasing attention is being paid to HVDC transmission systems, especially because most of the new schemes are intended to connect remote renewable sources to the grid and the most effective way to do it is to transmit the gener-ated power using HVDC instead of HVAC. For offshore HVDC applications, Voltage Source Converters (VSC) are more suitable than Current Source Converter (CSC) , thanks to their black-start capability and ability to operate in weak AC grids, such as a network of wind turbine generators. However, compared to CSC, their power ratings are limited and their efficiency somewhat poorer although recent developments in semi-conductor devices are closing the gap in both cases such that VSCs are becoming economically viable as technological solutions in large HVDC schemes; some of them, to be commissioned in the next couple of years.

Since the 1990s, a great deal of research effort has been directed to improving converters primarily to make them more power efficient than the first generation of VSC [5]– [8]. The Modular Multi-level Converter (MMC), published in 1998 for STATCOM application [9], published in 2003 for HVDC Power Transmission and followed up in, brought several new features to VSC. It replaced the series-connected IGBT in each arm of the 2-level converter by a stack of half-bridge cells which consist of a charged capacitor and a set of IGBTs. Given that the voltage of each cell is small compared to both the AC and DC voltages, a large number of cells are placed in series in each stack, resulting in the creation of a voltage waveform with numerous steps. This characteristic has two main consequences: (i) the generated AC current is very close to a sine wave and no longer requires any filtering, thus saving the implementation of bulky and costly AC filters and (ii) the converter does not rely on high-frequency PWM to syntheses voltage waveforms, thus greatly reducing the switching loss and thereby improving the overall efficiency of the converter.

Not withstanding the advantages brought by this new gen-eration of converter, there are some aspects that can still be improved. The avoidance of the AC filter means that the cells are now one of the bulkiest components of the converter station and cell format requires a physically large capacitor in addition to the set of IGBTs. Half-bridge cells are normally used in preference to H-bridge cells (both illustrated in Fig. 1) in order to reduce the number of devices in conduction at any time and therefore reduce the conduction power loss. Even if this choice is justified by the large cost associated with the power losses, it also means that the converter is vulnerable to a DC-side fault in a similar way to a 2-level converter whereas an H-bridge version would not be. The inability of half-bridge cells to produce a negative voltage results in the conduction of the anti-parallel diodes connected to the IGBTs, thus creating an uncontrollable current path in case of a collapse of the DC bus voltage. Given that DC breakers for high power applications are still under development, the lack of other fast protective mechanisms makes this loss of a means to control DC fault current problematic. In, the Double Clamped Submodule (DCS) was suggested as a new type of cell to deal with this issue.

The DCS connects together two half-bridge cells together into one cell through one additional IGBT and two diodes. This configuration offers the possibility of switching in a reverse voltage, similar to the H-bridge cell, in order to respond to the need for negative stack voltage in case of DC-side fault. However the DCS does not fully solve the DC fault issue because (i) only half the available positive voltage can be translated into negative voltage, leaving a voltage deficit from that needed to fully control the current, and (ii) the power losses are increased by 50% compared to using two half-bridge cells during normal operation because of the additional IGBT in the conduction path.

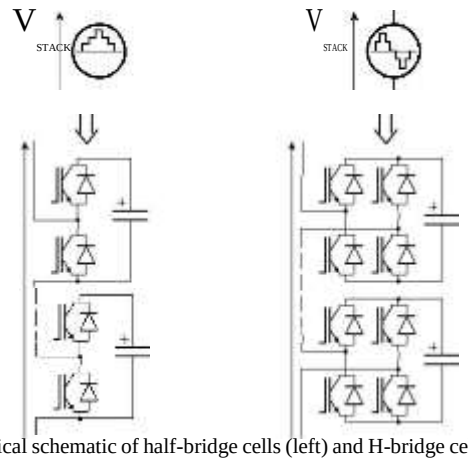

Fig. 1. Electrical schematic of half-bridge cells (left) and H-bridge cells (right).

This paper presents the analysis of a new converter topology, which is part of a new generation of VSCs, based on the multi-level approach but also takes some characteristics from the 2-level VSC. As explained through this paper, one of the features of this topology lies in its ability to retain control of the phase current during the loss of the DC-bus voltage, thanks to the presence of H-bridge cells in the arms. The key advantage of this new topology lies in its reduced number of cells, thus it does not compromise on the efficiency of the converter, nor on the number of devices and even saves volume because of the reduced number of cells per arm. A component level simulation of a 20 MW converter is used confirm the claimed characteristics of this new topology.

2. DESCRIPTION OF THE TOPOLOGY

A. Basic Operation

Briefly presented in, the Alternate Arm Converter (AAC) is an hybrid topology which combines features of the 2-level and multi-level converter topologies. As illustrated in Fig. 2, each phase of the converter consists of two arms, each with a stack of H-bridge cells, a director switch and a small arm inductor. The stack of cells are responsible for the multi-step voltage generation, as in a multi-level converter. Since H-bridge cells are used, the voltage produced by the stack can be either positive or negative, thus the converter is able to push its AC voltage higher than the DC terminal voltage if required. The director switch is composed of IGBTs connected in series in order to withstand the maximum voltage which could be applied across the director switch when it is in the open state. The main role of this director switch is to determine which arm is used to conduct the AC current. Indeed, the key feature of this topology is to use essentially one arm per half cycle to produce the AC voltage. By using the upper arm to construct the positive half-cycle of the AC sine wave, and the lower arm for the negative part, the maximum voltage that each stack of cells has to produce is equal to half of the DC bus voltage, which is approximately half the rating of the arm of the MMC.

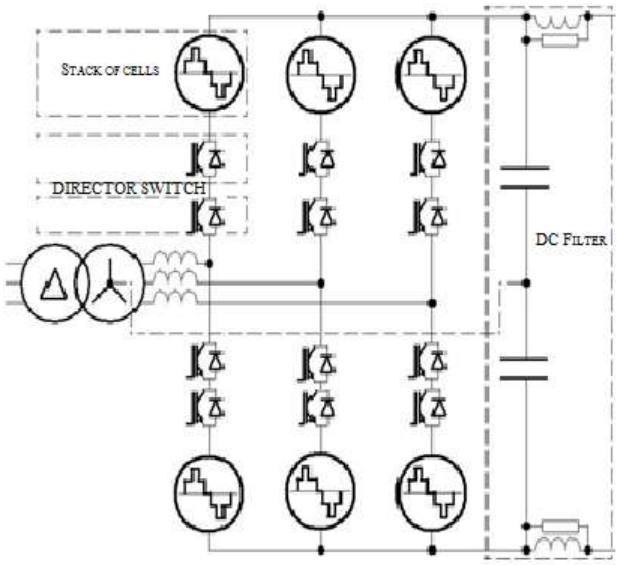

Fig. 2 Schematic of the Alternate Arm Converter, with the optional middle-point connection shown in dashed line.

The resulting voltage and current waveforms of the cells and reactor switches are illustrated in Fig. 3. The aim of the AAC is to reduce the number of cells, hence the volume and losses of the converter station.

The short period of time when one arm finishes its working period and hands over conduction of the phase current to the opposite arm is called the overlap period. Since each arm has an active stack of cells, it can fully control the arm current to zero before opening the director switch, hence achieving soft-switching of the director switch, further lowering the power losses. Although normally short, the overlap period can provide additional control features such as controlling the amount of energy stored in the stacks, as explained in section II-C

B. DC Fault Management

One of the important characteristics of this converter is the ability of its arms to produce negative voltage. In fact, the AAC already uses this ability to produce a converter voltage higher than the DC terminal voltage without requiring the opposite arm to also produce a higher than normal positive voltage from its stack of cells, provided that the director switch is suitably rated. This ability is put to use in normal operation when the converter produces a voltage which is higher than the DC bus voltage. It can be extended to the case when the DC bus voltage collapses to a low level, e.g. a fault on the DC-side. Given that enough cells are present in the stacks to oppose the AC grid voltage, the converter is thus able to keep all its internal currents under control, in contrast to the 2-level converter or half-bridge version of the MMC. Furthermore, even if the absence of a DC bus voltage means that it is no longer possible to export active power to the DC-side, it does not prevent reactive power exchange with the AC side. Since the arms of the AAC are still operational, the whole converter can now act as a STATCOM, similar to that in.

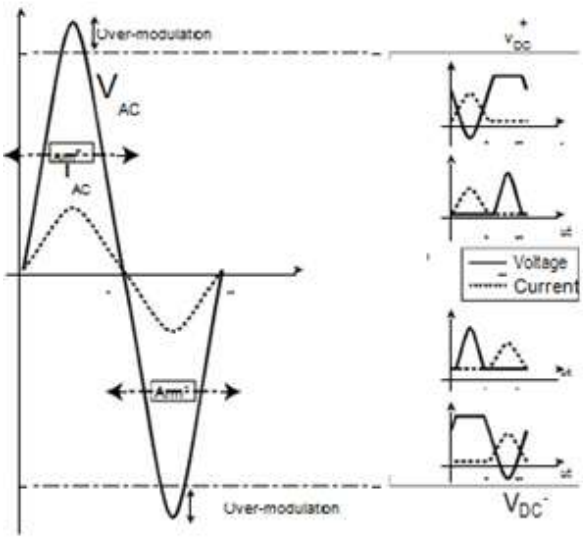

Fig. 3. Idealized voltage and current waveforms over one cycle in a phase converter of the AAC, showing the working period of each arm.

There are some choices over how the director switches are used in this mode, as illustrated in Fig. 4, which lead to different modes that can be achieved by the AAC during a DC-side fault: one arm conducts per half cycle similarly to normal operation, one arm works continuously or the two arms working together, potentially increasing the reactive power capability to 2.0 p.u.

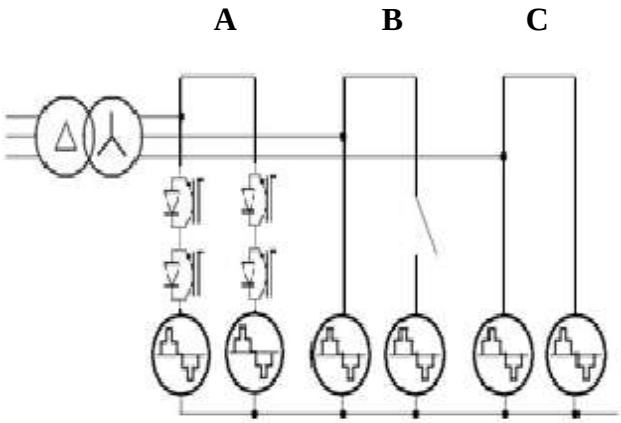

Fig. 4. STATCOM modes of the AAC during a DC-side fault: alternate arms (mode A), single working arm (mode B), dual working arms (mode C)

This STATCOM-mode of managing the converter during DC fault can help to support the AC grid during a DC outage, in contrast to the worsening effect that can be brought about by other topologies because of their inability to control DC-side fault current.

C. Energy balance

The ability of the converter to generate relatively fine voltage steps comes from its cells and, more specifically, from the charged capacitors inside. However, since the resultant AC current is flowing through them, the charge of these capacitors will fluctuate over time, depending on the direction of the current and the switching states of the cells. Due to the large number of cells, it is easier to look at the amount of energy which is stored by the stacks of cells as a whole. Assuming that this charge is evenly distributed among the various cells, thanks to some rotation mechanisms, the only requirement left to ensure satisfactory operation of the converter is to keep the energy of the stacks close to their nominal value. To achieve this, the converter has to be operated in such way that the net energy exchange for the stacks over each half cycle is strictly zero. Based on the time functions (1) of $V_{AC}(t)$ and $I_{AC}(t)$

$$\begin{aligned} V_{\mathrm{AC}}(t) &= \hat{V}_{\mathrm{AC}} \sin(\omega t) \\ I_{\mathrm{AC}}(t) &= \hat{I}_{\mathrm{AC}} \sin(\omega t + \phi_{\mathrm{AC}}). \end{aligned} \tag{1}$$

The energy exchange corresponds to the difference between the amount of energy coming from the AC side (2) and going to the DC-side (3).

$$\begin{aligned} E_{\mathrm{AC}} &= \int_0^{\frac{T}{2}} V_{\mathrm{AC}}(t) I_{\mathrm{AC}}(t) dt \\ &= \frac{\hat{V}_{\mathrm{AC}} \hat{I}_{\mathrm{AC}} cos(\phi_{\mathrm{AC}}) T}{4} \end{aligned} \tag{2}$$

$$\begin{aligned} E_{\mathrm{DC}} &= \int_0^{\frac{T}{2}} \frac{V_{\mathrm{DC}}}{2} I_{\mathrm{AC}}(t) dt \\ &= \frac{V_{\mathrm{DC}} \hat{I}_{\mathrm{AC}} cos(\phi_{\mathrm{AC}}) T}{2\pi}. \end{aligned} \tag{3}$$

By equating these two energies, an ideal operating point is identified as described in Equation 4. This operating point is called the 'sweet spot' and is defined by a ratio of the AC voltage magnitude to DC voltage magnitude.

$$\hat{V}_{\mathrm{AC}} = \frac{2}{\pi} V_{\mathrm{DC}} \Longleftrightarrow V_{\mathrm{line}} = \frac{2}{\pi}\sqrt{\frac{3}{2}} V_{\mathrm{DC}}. \tag{4}$$

It is important to remark that this sweet spot specifies an AC peak voltage higher than the DC terminal voltage, i.e. half the DC bus voltage. The converter is thus required to generate its AC voltage in over-modulation mode, at a level approximately 27 % higher than the DC terminal voltage (~4/π(Vdc/2)) The presence of H-bridge cells is thus fully justified since these cells are required to provide a negative voltage, thus pushing the voltage higher than the DC terminal voltage. By choosing the turns-ratio of the transformer between the converter and the AC grid in order to obtain the AC voltage of the sweet-spot, the converted energy will flow through the converter without a deficit or surplus being exchanged with the stacks.

In practice, discrepancies between the converter and its theoretical model (used to derived Equations (2) and (3) leading to Equation (4)) will lead to a small fraction

of the converted energy being exchanged with the stack. To remedy this, the overlap period (i.e. the small period of time when one arm hands over conduction of the phase current to the other arm) can be used to run a small DC current through both arms to the DC-side. This will result in an exchange of energy between the stacks and the DC capacitor, which can be used to balance the energy in the stacks.

D. Number of Devices

The device count in the AAC can be obtained by following a series of steps, given the particular operating mechanism described before. The calculation presented below only gives the minimal requirement under normal operation. An additional margin has to be added to comply with the different operating conditions applied to each project. It is, however, important to note that the stacks of the AAC can generate as much negative voltage as positive voltage; thus, the AAC is able to provide an ac voltage up to 200% of the dc terminal voltage without requiring extra cells.

First, the number of cells is obtained by calculating the maximum voltage that a stack has to produce. Since the two arms of a single-phase converter have to support at least the total dc bus voltage, and assuming a symmetrical construction, this maximum voltage has to be at least half the dc bus voltage. Furthermore, given that this topology is intended to have dc-fault blocking capability, the arms should be able to produce at least the ac peak voltage in order to maintain control over the current in the phase reactor with the dc voltage reduced to zero. Therefore, the stacks should be rated to deliver the ac peak voltage. Since the sweet spot defines the ac peak voltage as 27% higher than half the dc bus voltage, the minimum requirement can then be increased up to the ac peak voltage. However, if dc-fault blocking is not a requirement, this voltage can remain at half the dc bus voltage. Furthermore, the maximum voltage of the stacks also defines how long an arm can stay active beyond the zero-crossing point of the converter voltage in order to provide an overlap period. The longer the overlap period, the higher the voltage that the stack has to produce, hence the more cells are required. Once the maximum voltage of the stack is set, the number of cells is directly obtained by dividing this voltage by the nominal voltage of a cell.

Second, the required number of series IGBTs, which form the director switch, is determined based on the maximum voltage applied across the director switch, as illustrated in Fig. 3. This voltage is the difference between the converter voltage and the voltage at the other end of the director switch, which is connected to the (nonconducting) stack of cells. The nonconducting stack can be set to maximize its voltage in order to lower the voltage across the director switch, taking care not to reverse the voltage across the director switch. Equation (5) summarizes all of these arguments and presents the maximum voltage across the director switch. By implementing the sweet spot definition (4) into (5), it yields (6), a function of the dc bus voltage and the peak stack voltage.

$$\hat{V}_{\text{Director}} = \hat{V}_{\text{AC}} + \frac{V_{\text{DC}}}{2} - \hat{V}_{\text{Stack}} \tag{5}$$

$$= \frac{4+\pi}{2\pi} V_{\text{DC}} - \hat{V}_{\text{Stack}}. \tag{6}$$

Table I summarizes the voltage ratings required of the stack of cells and the director switch given three choices made over the need to block dc fault current and the extent of overlap. In defining these voltages, these choices will also determine the number of semiconductor devices in the AAC.

TABLE I
Voltage ratings of the stacks and director switches

$\hat{V}_{\text{Stack}}$	$\hat{V}_{\text{Director}}$	Remarks
$\frac{V_{DC}}{2}$	$\hat{V}_{AC}$	No DC-fault blocking and no overlap
$\hat{V}_{AC}$	$\frac{V_{DC}}{2}$	DC-fault blocking and short overlap
$\hat{V}_{DC}$	$\hat{V}_{AC} - \frac{V_{DC}}{2}$	DC-fault blocking and full cycle overlap

The resulting number of cells per stack is given by (7), where (Vcell) is the nominal voltage of a cell

$$N_{\text{Cell}} = \frac{V_{\text{Stack}}}{V_{\text{Cell}}}. \tag{7}$$

Equation (8) presents the total number of semiconductor devices (N_{IGBT}) in a three-phase AAC, with being the number series-IGBTs in the director switch obtained by dividing the maximum voltage of a director switch ($V_{Director}$) by the voltage applied to an IGBT, here assumed to be the same to the voltage of a cell (V_{Cell}).

$$N_{\text{IGBT}} = 6 \times (4 \times N_{\text{Cell}} + N_{\text{Director}}). \tag{8}$$

Using the dc-fault blocking case (given in Table I) and the definition of the sweet spot (4), the total number of semiconductor devices becomes the value of the following equation:

$$N_{\text{IGBT}} = 6\frac{4\hat{V}_{\text{AC}} + \frac{V_{\text{DC}}}{2}}{V_{\text{Cell}}} \approx 18.28\frac{V_{\text{DC}}}{V_{\text{Cell}}}. \tag{9}$$

3. SIMULATION RESULTS

A. Model Characteristics

In order to confirm the operation of this new topology, a simulation model has been realised in Matlab/ Simulink using the SimPowerSystems toolbox. The characteristics of this model have been chosen in order to reflect a realistic power system, albeit at medium voltage (MV), and key parameters are summarized in Table II. The transformer interfacing the ac grid and the converter has its turns ratio defined such that the converter operates close to the sweet-spot ac voltage, as defined in Section II-C. The number of cells chosen for each stack follows the second case from Table II so that dc-side fault blocking is available. A small additional

allowance was made so that the converter can still operate and block faults with an ac voltage of 1.05 p.u. The choice is therefore for nine cells charged at 1.5 kV each per stack. The minimum number of cells for operation without overlap (sweet spot operation only) and without fault blocking would be seven cells. The choice of nine cells per stack allows the AAC to operate with 1-ms overlap period which is sufficient to internallymanage the energy storagewithin the current rating of the IGBTs (1.2 kA). Finally, a dc filter has been fitted to the AAC model, as illustrated in Fig. 2, and tuned to have critical damping and a cutoff frequency at 50 Hz; well below the first frequency component expected on the dc side which is a six-pulse ripple (i.e., 300 Hz in this model).

TABLE II
CHARACTERISTICS OF THE AAC MODEL

Characteristics	Values
Active power	±20 MW
Reactive power	±5 MVAr
DC bus voltage	20 kV
Grid-side AC voltage	11 kV
Converter-side AC voltage	15.56 kV
Phase reactor	3.9 mH
Arm inductor	0.5 mH
DC Filter inductors (x2)	6 mH
Quality factor of DC inductors at 50 Hz	100 (19 $m\Omega$)
DC Filter capacitors (x2)	1.68 mF
Total energy in DC bus capacitors	168 kJ
DC Filter resistors (x2)	2.66 Ω
Overlap period	1.0 ms
Cell voltage	1.5 kV
Cell capacitor	4.0 mF
Stacks	9 cells
Director switches	7 IGBTs
Converter voltage waveform	**19 levels**
Total number of semiconductor devices	**258 IGBTs**

B. Performance under normal conditions

Based on this model, the behavior of the AAC was simulated under normal conditions in order to test its performance. In this section, the converter is running in rectifier mode, converting 20 MW and providing 5 MVAr capacitive reactive power. Figure 5 shows the waveforms generated by the AAC in this simulation.

First, the converter is very responsive. Second, the wave-form of the phase current in the AC grid connection is high quality with only very low amplitude harmonics, as shown by the Fourier analysis in Fig. 6. Third, the DC current exhibits the characteristic 6-pulse ripple inherent in the rectification method of this converter, but attenuated by an inductor placed between the converter and the DC grid. Fourth, this rectification action of the current is particularly observable in the fourth graph which shows the arm currents in phase A, indicating when an arm is conducting. Finally, the fifth graph presents the average voltage of the cells in both stacks of phase A, with their off-state voltage being controlled to stay at the reference value of 1.5 kV.

The voltage and current waveforms have been post-processed together with the switching commands sent to the converter from the controller, in order to determine the generated power losses. For this example, all the semiconductor devices were based on the same IGBT device [21] from which the losses curves have been extracted to compute the energy lost through conduction and switching at every simulation time step (2 μs). A simulation of 1.5 s was used in which the first 0.5 s was ignored in order to focus only on the steady state portion

The results obtained are summarized in Table III. As can be observed in Table III, the switching loss relative to the total power losses is low, as could be expected from a multi-level converter, meaning that the conduction loss is dominant. However, the conduction loss is kept small despite the use of H-bridge cells by the fact that the stacks do not have to be rated for the full DC bus voltage because of the presence of the director switches; the conduction loss of a director switch device being less than that of an H-bridge cell. The director switches do not incur any switching loss thanks to the soft-switching capability of the arms (through controlling the arm current to zero before opening of the director switch).

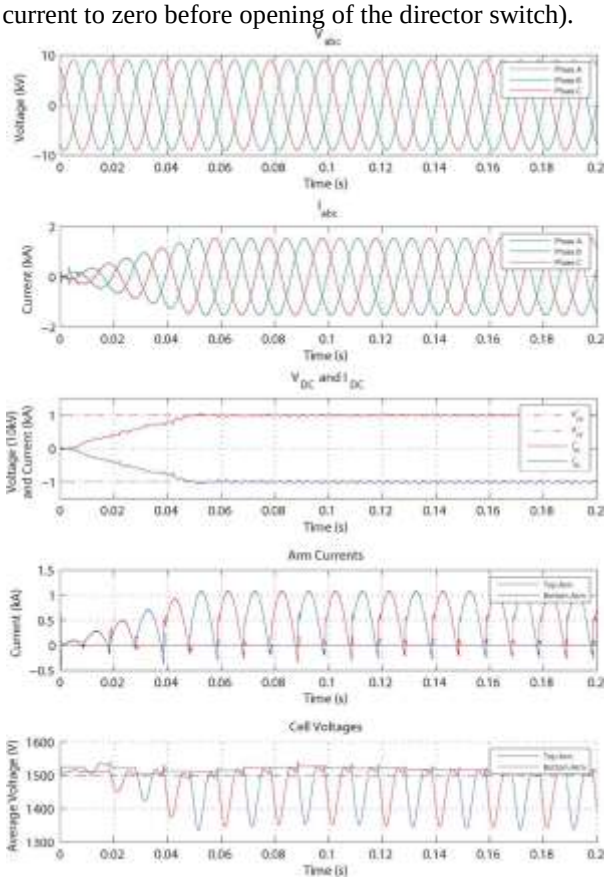

Fig. 5. Simulation results of a 20-MW AAC model running in rectifier mode under normal conditions.

C. DC Fault Blocking Capability

The intended ability to block current during dc faults was tested by simulating the temporary reduction of the dc bus voltage to zero, equivalent to a dc-side fault. The

graph in Fig. 8 shows the waveforms generated during this simulation, where the dc bus voltage is lost between 0.20 and 0.35 s followed by a ramp up back to normal operations. When observing the sequence of events during this simulation, it can be seen that when the dc voltage collapses to zero, it leads to a rapid discharge of the dc bus capacitor which is outside the control of the converter in opposition to the cell capacitors. At the moment of fault, the dc filter behaves similar to an RLC circuit with a precharged capacitor (20 kV) and inductor(1 kA), resulting in a theoretical peak current of 5.1 kA which is close to the current spike observed in the third graph. However, the fourth graph shows that the converter is able to keep control of the ac reactor current and its arm currents so that no fault current flows from the ac side to the dc side, demonstrating the dc fault blocking capability of the converter itself. Since the converter is no longer able to exchange active power with its dc bus voltage at zero, the active currents are controlled back to zero. Then, from 0.25 s, the AAC starts injecting 1.0-p.u. reactive current, thus acting as a STATCOM supporting the ac grid during the outage of the dc link. The stack in conduction at the instance of the fault sees its stored energy rise because it temporarily stores the still incoming energy (while the active current is being reduced), but converges back to its reference value over the period when the fault is present. Finally, when the dc voltage has returned, the converter is able to resume operation quickly. This simulation shows the ability of the AAC to cope with the dc-side fault and even run as a STATCOM to support the ac grid, in the absence of dc bus voltage. Furthermore, in the current simulation, the AAC keeps the same alternating mechanisms of its arms (mode A in Fig. 4) but, by activating both arms continuously (mode C in Fig. 4), the maximum reactive power could reach up to 2.0-p.u. current.

Finally, a large amount of the power losses comes from the dc inductor but this is not representative of a large converter. In this scale model of 20MW, the current at 1 kA is typical of a much later converter and it is the voltage that has been scalded down by reducing the number of cells and levels (while keeping the cell voltage at value typical of a larger converter 1.5 kV). Since the Q factor of the inductor and the current have not been scaled, the I^2 R loss in the inductor is proportionately large.

TABLE III
BREAKDOWN OF THE POWER LOSSES AT 20 MW

Stack power losses	Value
Conduction	103 kW
Switching	26 kW
Reverse Recovery	10 kW
Director switch power losses	**Value**
Conduction	36 kW
Switching	0 kW
Reverse Recovery	0 kW
DC-filter power losses	**Value**
Conduction	56 kW
Total Power Losses	**191 kW**
Efficiency	**98.85 %**

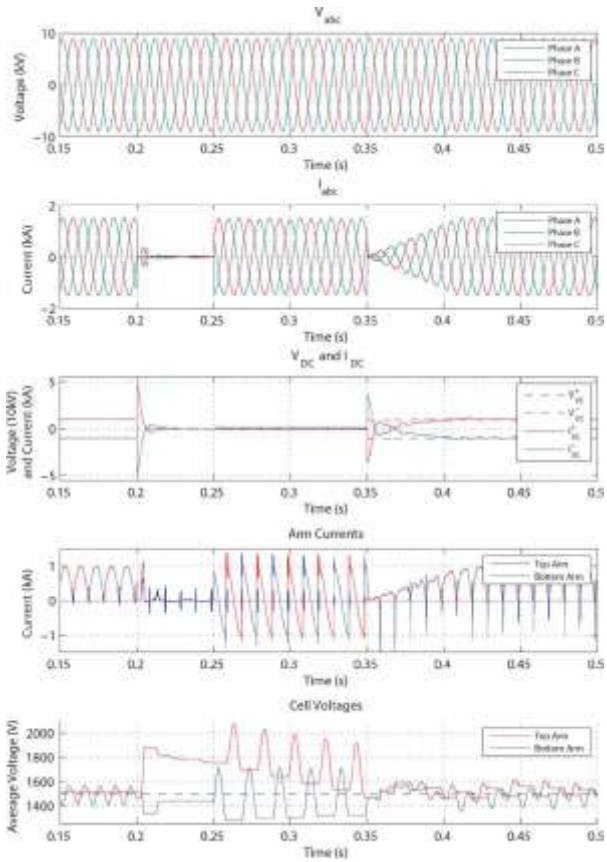

Fig. 6. Simulation results of a 20-MW AAC model running in rectifier mode when a dc-side fault occurs between 0.20 and 0.35 s.

4. CONCLUSION

The AAC is a hybrid topology between the two-level converter and the modular multilevel converter. By

combining stacks of H-bridge cells with director switches, it is able to generate almost harmonic-free ac current, as does the modular multilevel approach. And by activating only one arm per half cycle, like the two-level converter, it can be built with fewer cells than the MMC. Since this topology includes cells with capacitors which are switched into the current path, special attention needs to be paid to keeping their stored energy (equivalently, the cell capacitor voltage) from drifting away from their nominal value. By examining the equations, which govern the exchange of energy between the ac and dc sides, an ideal operating condition has been identified, called the "sweet spot." When the converter is running at this condition, the energy levels of the stacks return to their initial values at the end of each cycle without any additional action. In cases where this equilibrium is not attained, an overlap period can be used to run a small dc current in order to balance the stacks by sending the excess energy back to the dc capacitors. A discussion of the total number of devices required by this topology has also been presented. Providing dc fault blocking and overlap both require more than the bare minimum number of cells, and adding cells does lead to increased conduction power loss which gives rise to a design tradeoff. Simulations of a small-scalemodel show that this converter is able to deliver performance under normal conditions, in terms of efficiency and current waveform quality, and provide rapid responses in the case of ac- or dc-side faults. Its ability to keep control of the current even during dc faults is a significant advantage, especially in multiterminal HVDC applications, and can be extended into STATCOM operation in order to support the ac grid during the outage, by providing potentially up to 2.0-p.u. reactive current.

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Developing a Comprehensive Library Management System for Tamale Polytechnic

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Abstract: The numerous problems of borrowing and returning books and maintaining comprehensive user profiles in the Tamale Polytechnic's library using the current manual system is seriously affecting the overall productivity of the facility. The impact of which is the poor and inefficient delivery of service to members. Since issuing of books is done by several librarians, details of which librarian issued or received a borrowed book is always not accurate and can easily be manipulated by individuals with their personal interests. A successful solution would be a computerized System for monitoring all transactions, members, user accounts, keep proper records of login details of users as well as effective generation of reports. All transactions that occur within the library are recorded automatically. It also has a fine and ad-hoc report generation mechanisms.

Keywords: successful; computerised; automatically; problems; transactions

1. INTRODUCTION

The proposed System is automated for managing the activities of the Tamale Polytechnic library. It is a secured system where only authenticated users are allowed access into it using a password protection mechanism. If a user fails to login successfully after three attempts, that particular user's account is locked. It is only the administrator who can unlock that user. Another significant security feature about the system is its ability to automatically record the date and time a particular user logs in and out the system. The system keeps records of all media and members of the library. All transactions that occur in the library are recorded automatically. It also has a fine generation mechanism as well as ad-hoc report generation feature.

2. OBJECTIVES OF THE PROPOSED SYSTEM

The proposed System is automated for managing the activities of the polytechnic library. Such system must be very secured whereby the software can be accessed only by the authenticated user using the password protection mechanisms.[1] If a user fails to login after three attempts, that particular user's account is locked. It is only the administrator who can unlock that user. Another significant security feature about the system is its ability to automatically record the date and time a particular user logs in and out the system.

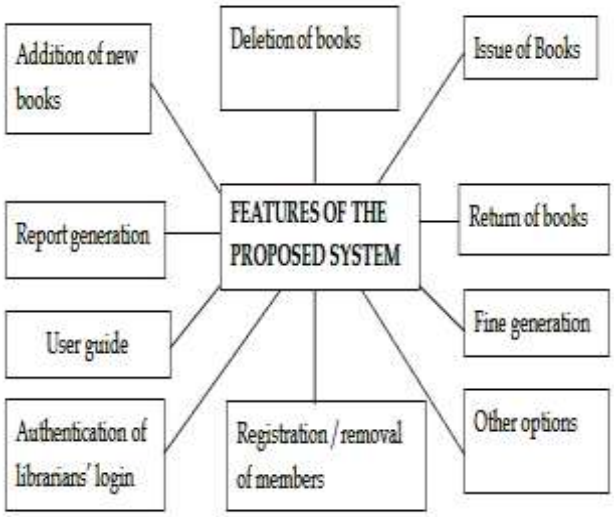


Figure 1 Objectives of the proposed system

3. BASIC THEORY

3.1 Programming Language Used

The project employed Visual Basic .NET (VB.NET) which is an object-oriented programming language which is a transformation of the classic Visual Basic (VB) developed on the .NET Framework. The .NET Framework is software that runs primarily on Microsoft Windows.[2] It includes a large library and supports each language using codes written in other languages.

3.2 SQL Server 2005

Microsoft SQL Server 2008 is the database backend for the library Management system. It includes native support for handling XML and relational data. For this reason, it defines an xml data type that could be used either as a data type in database columns or literals in queries.[4] Columns in XML can be associated with XSD schemas; data in XML is being stored is authenticated against the schema.

4. SYSTEM DESIGN

4.1 Analysis of Existing Project Management System

Currently, almost all transactions in the Tamale Polytechnic library system is done manually.

Main features of the current system are:

- Large volume of books and student's data are maintained in the form of **registers**.

- **Issue Procedure:** A Student can be issued three (3) books at a time using the allotted issue cards to him. The librarian takes off the book card from the book in which all the details of the book are written. He attaches the book card with the issue card of the student and places it in the record column.
  It is to be noted that the issue card has to be placed in the sorted fashion, sorted in columns by class (i.e. Primary Key) and any sorting collisions are handled by sorting by secondary key i.e. the students Matric number.

- **Book return procedure:** Student is required to return the book within the due date. the book is taken by the librarian then the issue card of that student is taken out from the sorted records (with the book card attached with the library issue card), then the book card is again placed in the respective book and the issue card is returned to the student by cutting of his entry from the book card indicating that the student no longer holds that book with him. If the book is not returned within the due date then the fine is calculated.

- In the course of adding new books, three registers are maintained by the library staff; Register of Authors, register of Books Title, Register of books sorted by accession number. These registers are needed as a catalogue for searching a particular book and determining whether it is present in library or not.
  New arrivals of the books are appended to books register and a notice is put up on the library notice board to inform the students about it.

- **Fine system:** It is required by the librarian to calculate the fine which is paid by the student on not returning the book within the return date of the book. Librarian sees the issue book register and checks the issue date and return date along with the student's details. The cost of the fine is GH 2/day for a book and is calculated as the difference between the current date and the return date.

4.2 Problems with the Current System

- No backup can be maintained as the data is large and duplication of data consumes lot of time.
- Analysis on data and access to database is tedious.
- Inability to obtain the status of a book rapidly.
- Modification of the details of Student/Book is a large process and may lead to chaos and is prone to errors.
- It is very difficult to search a particular book entry as all the book registers are looked which requires very large work force and is a tedious and cumbersome process.

4.3 Data Flow Diagram (DFD)

Data Flow Diagram (DFD) provides an indication of how data are transformed as they move through the system. It also depicts the function that transforms the data flow.[6][1]

4.3.1 Context Diagram

Context diagrams in DFD show the overall information and entity in an application.[6] This is presented below;

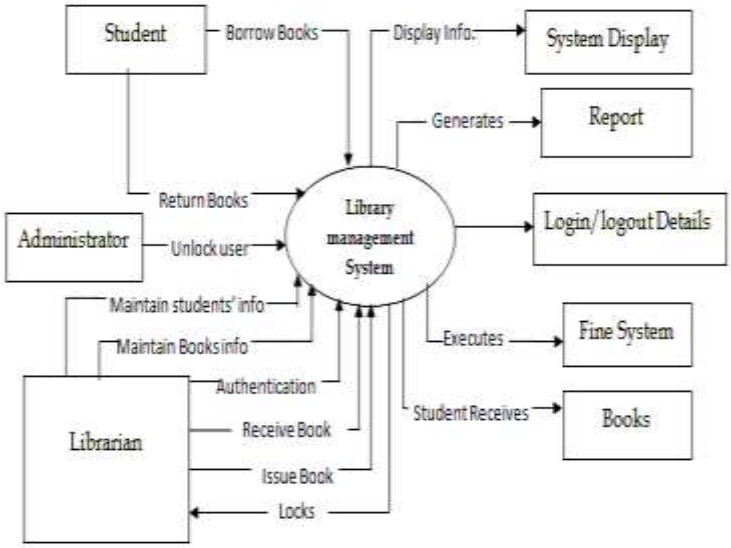


Figure 2 Context level DFD

4.3.2 Level 1 DFD

The Level 1 DFD outlines how the proposed system is divided into sub-systems (processes), each of which deals with one or more of the data flows to or from an external agent, and which together provide all of the functionality of the system as a whole. It also identifies internal data stores that must be present in order for the system to do its job, and shows the flow of data between the various parts of the system. [7][5] The figure below shows the level 1 DFD used for the system;

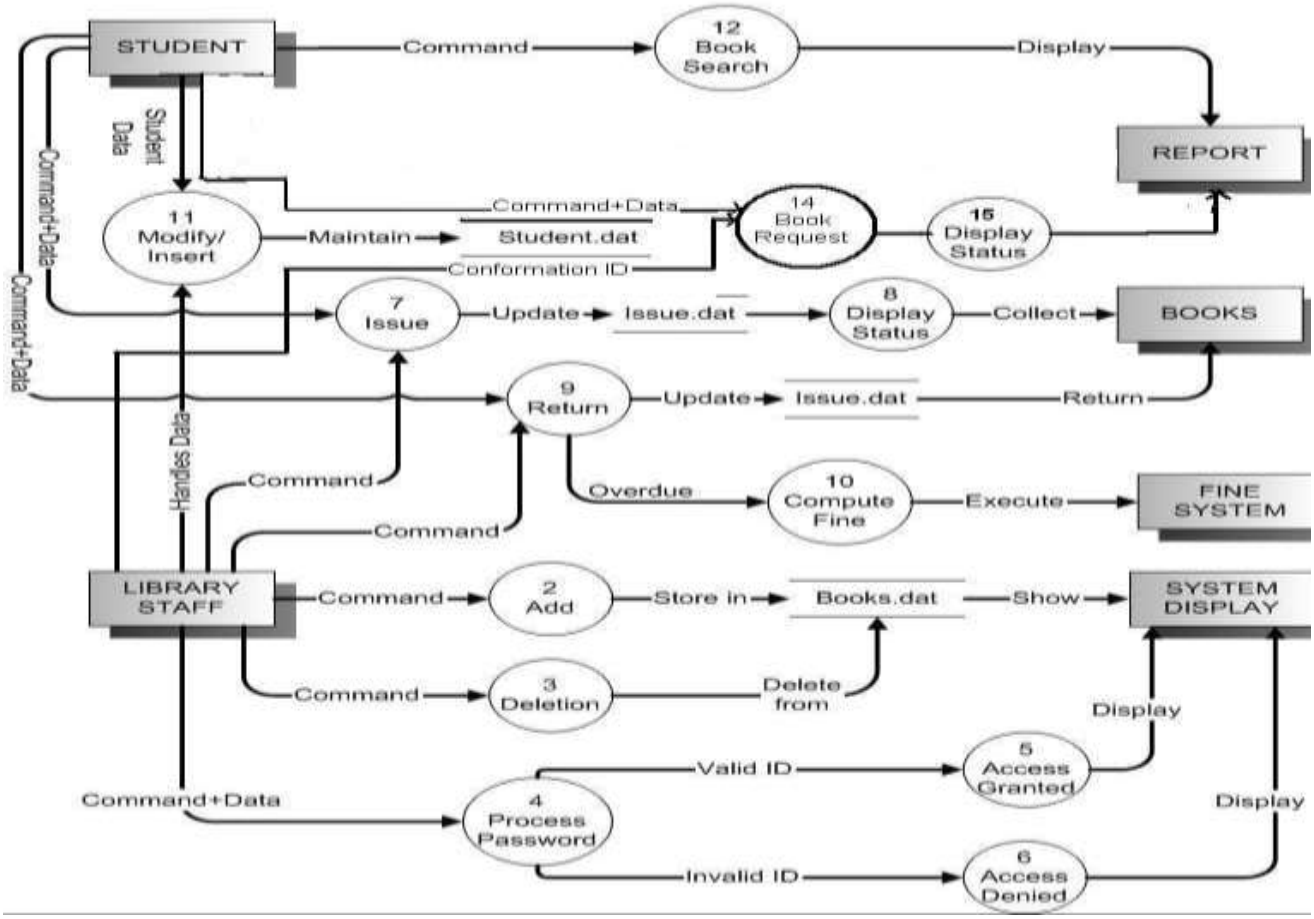


Figure 3 LEVEL 1 DFD

4.4 Entity Relationship Diagram (ERD)

The ERP specifies the relationships between data objects and attribute of each data object can be described using a data object description.[3][4]

The entity relationship model for the application can be seen in Figure 4 below.

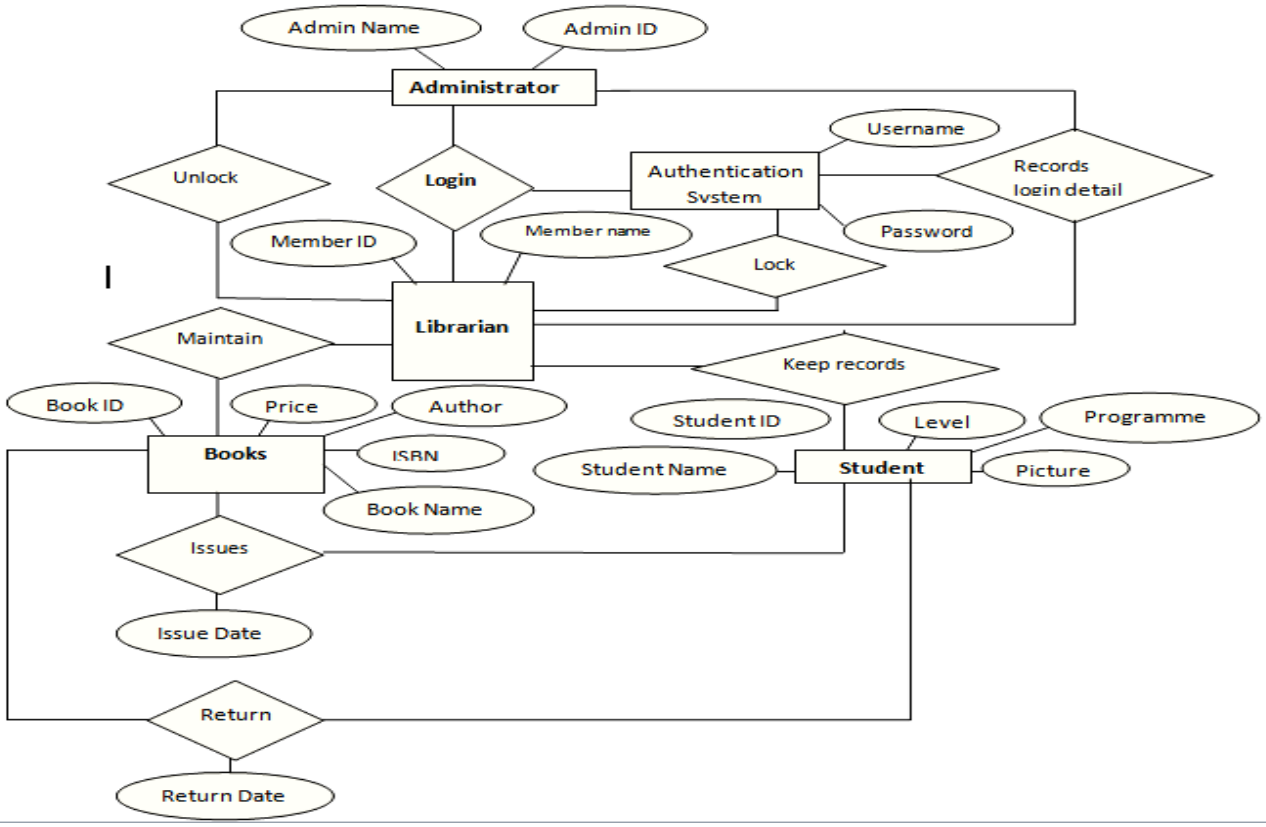


Figure 4 E-R Diagram of the Proposed System

4.5 Application Implementation

This section is divided into sub-sections in which each is going to feature a short explanation and a screenshot of the a particular feature of the proposed system .

4.5.1 User authentication form

A user provides a username and a password to login into the system. However if a user fails to login after three attempts, his/her account is locked automatically. At this point it is only the system administrator who can unlock the user and possibly reset the password. The system also records the date and time a particular user logins in and out the system. Fig. 5 below depicts that.

Figure 5 Login Form

4.5.2 Book form

Book Issuing Procedure: A Student can be issued a book provided it is available and not already issued to another student. Once the librarian clicks on the issue option, all the books available for borrowing are automatically displayed. The student ID is entered and all detail related information about the student appears. The librarian also clicks on the book the

student wishes to borrow and automatically its detail information is also retrieved. The procedure checks for the case when the book is already issued to some other borrower or the book is not present in the library and thus the book is not available for issuing. The librarian does not need to enter the issuing date since the current date is automatically used and then the validations for the date are performed. However the return date will have to be entered by the librarian.
New arrivals of the books are appended to the books database and the number of books in the library is incremented by 1. The screen shot in fig 6 below depicts that.

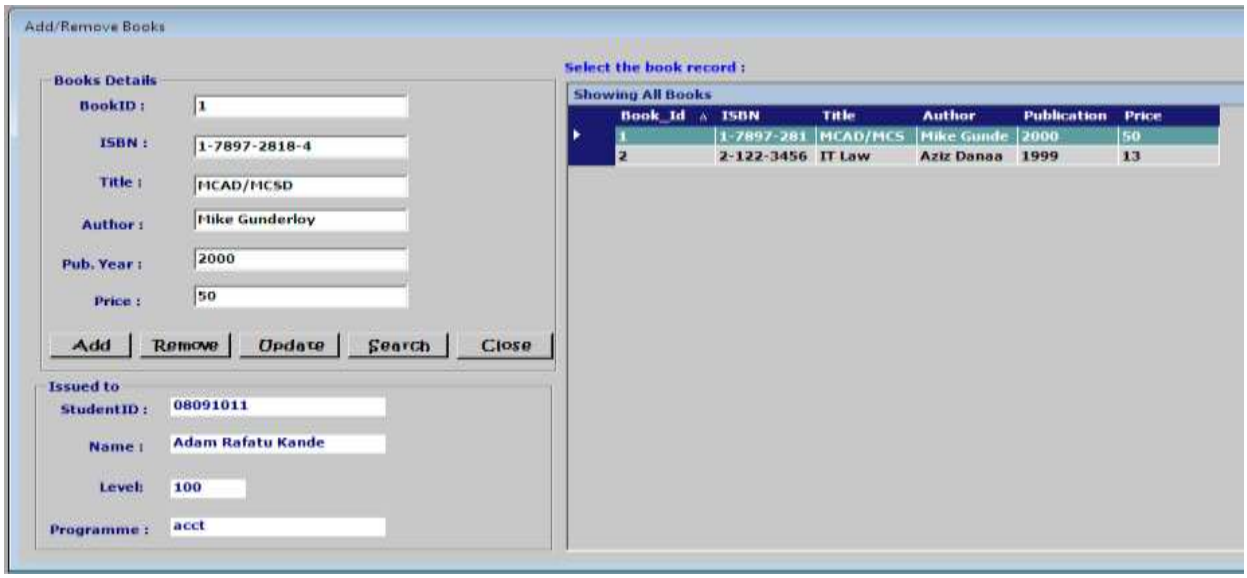


Figure 6 Books Form

4.5.3 Students Form

New student records are added to the database using the form in fig. 7 below, where the student is allowed to borrow up to a maximum of books specified by the systems administrator. Pictures of students are also captured to prevent impersonation.

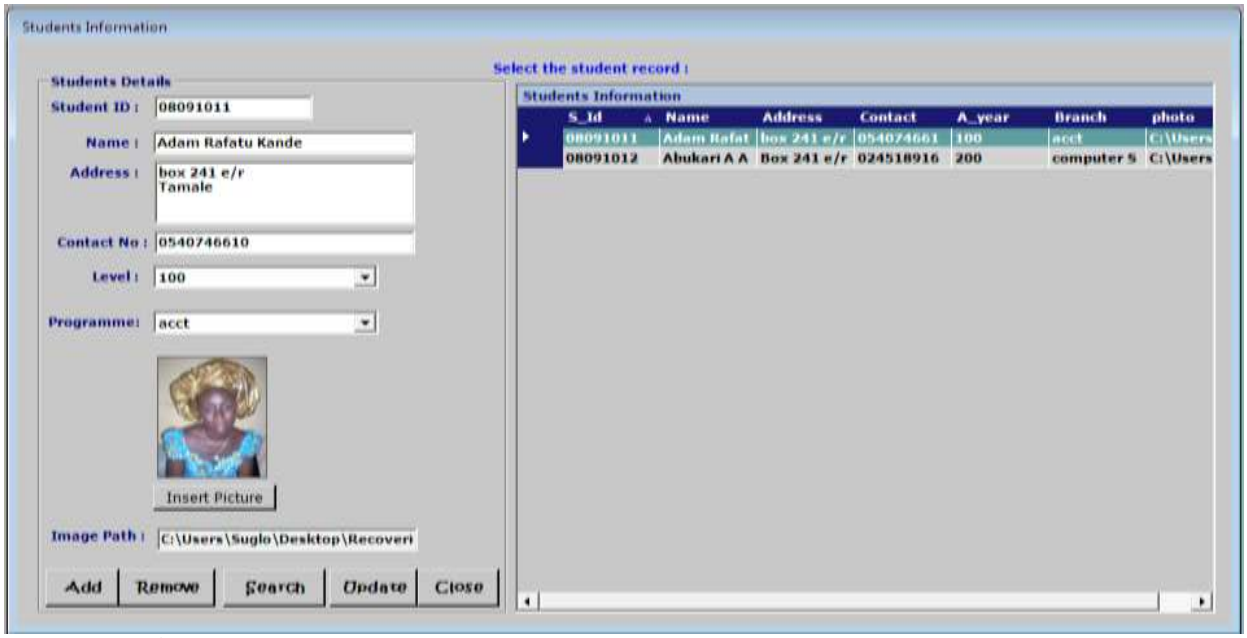


Figure7 Students form

4.5.4 Transaction Form (return Option)

A Student is required to return the book before/on the due date otherwise he has to pay the fine which is calculated and generated by the system automatically based on the interval between the return date and the date of issuing. Once the librarian clicks on the Return option, all borrowed Books are automatically displayed along with students currently keeping those books. The issued and return dates of those books are also displayed. The librarian clicks on the books to be returned and necessary information about the book and the student is retrieved. He then clicks on the return button and the book is returned. A screen shot is illustrated in the figure below;

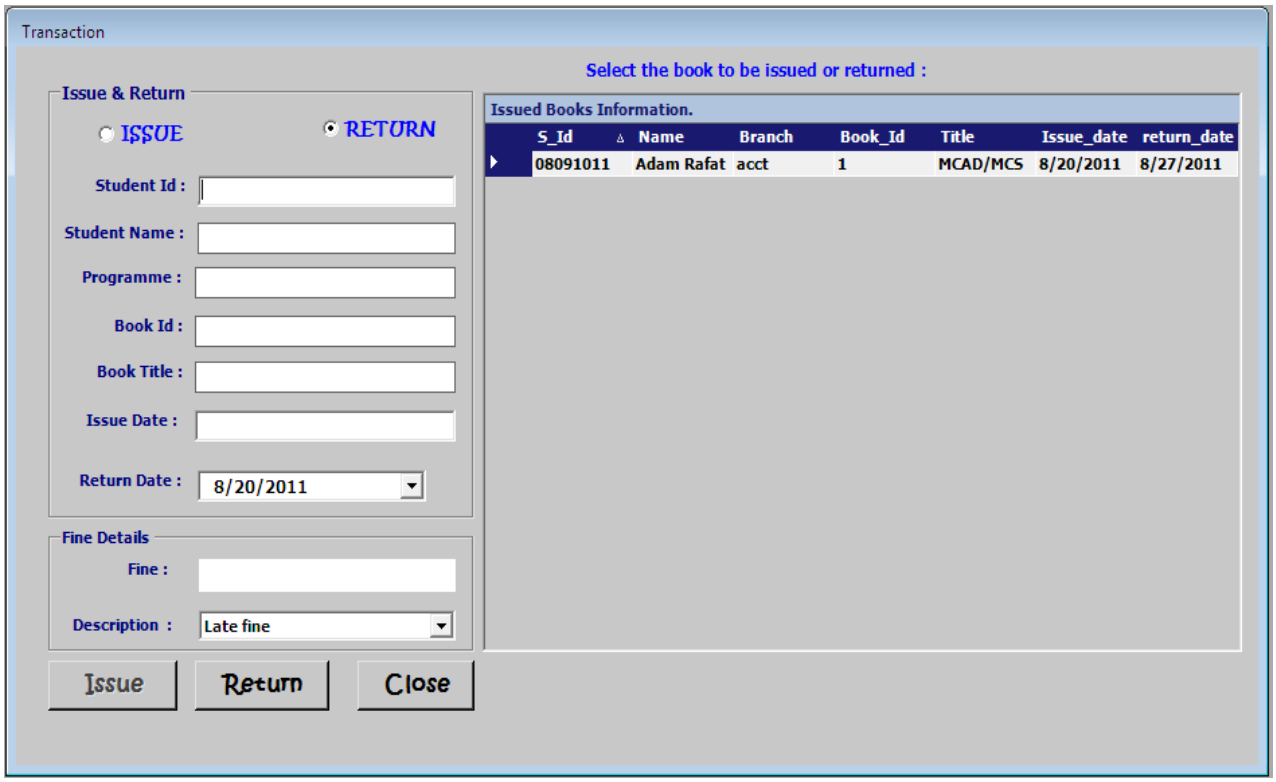


Figure 8 Transaction form

4.5.5 Options Form

The system generates a **fine** as prescribed by management of the library. The Return date of books is generated according to a predetermined time interval. If the book is not returned before the return date arrives then fine is automatically calculated and the student is charged to pay that amount. Figure 9 below shows how the fine and the number of books a student can borrow at a time is determined.

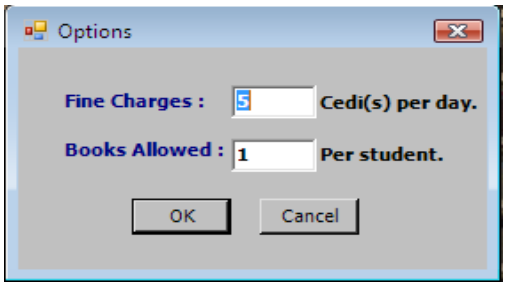


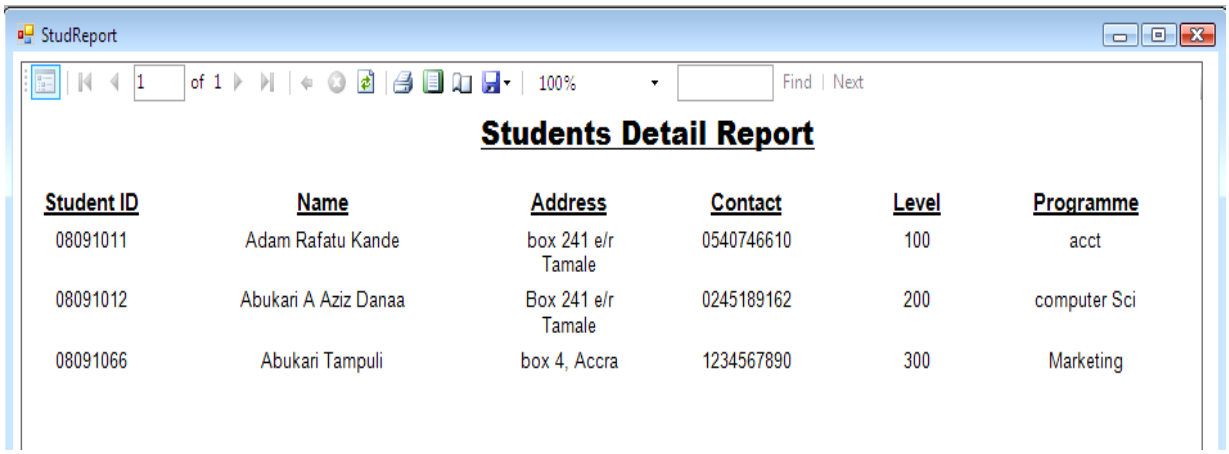
Figure 9 Options form

4.5.6 Report generation

The system incorporates report generation and filtering mechanisms. Reports can be built on the basis of the following criteria:

- ✓ List different books present in the library with the columns separated under different fields viz. Author name, Edition number, category, ISBN, Book ID and status of the book whether the book is issued or not.
- ✓ View the details of books currently issued.
- ✓ View the books present in the library that is the books which have not been issued by any of the borrowers.
- ✓ Details of students who are currently issued books with the details of the books.
- ✓ Fine report
- ✓ A detailed log report of users.

Figure 10 below shows a sample report of current students in the library;



Student ID	Name	Address	Contact	Level	Programme
08091011	Adam Rafatu Kande	box 241 e/r Tamale	0540746610	100	acct
08091012	Abukari A Aziz Danaa	Box 241 e/r Tamale	0245189162	200	computer Sci
08091066	Abukari Tampuli	box 4, Accra	1234567890	300	Marketing

Figure 10 Students Detail Report

5. CONCLUSION

Based on the results of application implementation, the following has been concluded;

1. On the part of the library staff, a lot time in issuing, returning and searching for the details of books and students which could be saved and channeled into a more productive and innovative business for the library.
2. Also, this project is very useful to students as they can access materials on time.
3. Generation of reports is enhanced which is useful in taking key strategic decisions regarding the library.
4. Staff cannot manipulate the system for their personnel interest since the generation of fine and the number of days a student keeps a book is predetermined in the system.
5. 35% survey respondents argued that the overall application is good whilst 60% argued that the overall application is very good. However, about 5% feel the system needs improvements from the survey results, it can be concluded that the application has met the requirements set by the Tamale Polytechnic's Library.

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Assessment of Tractor Maintenance Practices of Tractor Operators at Ejura, Ghana

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Abstract: Tractors are very expensive and complex machines, hence they need to be well operated and maintained so as to preserve their service life and maximise their profitability. A survey involving 101 tractor operators was conducted at Ejura in the Ejura-Sekyedumasi District of the Ashanti Region of Ghana to assess their expertise in tractor operation and maintenance and their attitudes towards recommended maintenance practices. It was revealed that 62% of the operators have no formal training in tractor operation while 60% of them have had some sort of training in tractor maintenance. Tillage operations, which are the most strenuous operations, are the major operations carried out with tractors at Ejura as they represent 97% of the responses. Generally, the operators are mindful of lubrication practices such as oil change and greasing, and the general cleanliness of their tractors and their components. However, about 78% of them do not have their hour metres in working condition and therefore it cannot be guaranteed that their frequency of oil change and greasing are according to manufacturer's recommendations. Also, 97% of them store their tractors in the open space which exposes them to environmental conditions that cause metal parts to rust. Only about 25% of the operators are in possession of manufacturer's maintenance instructions out of which 80% adhere to the instructions in maintaining their tractors. As majority of them do not have their hour metres and thermostats operational, it could be said that operators' attitudes toward recommended maintenance operations are not appropriate.

Keywords: Tractor, tractor operators, operation, maintenance, daily checks

1. INTRODUCTION

Low level of agricultural mechanisation inhibits agricultural production and threatens food security (Alabadan and Yusuf, 2010). In Ghana, most farmers are small holders who make use of hand tools and implements which involve drudgery and places severe limitations on the size of land that can be cultivated. The use of hand tools reduces timeliness of farm operations and limits the effectiveness of essential operations such as cultivation and weeding, thereby reducing crop yield (Sims and Kienzle, 2006). Hence, mechanising agriculture through the adoption and appropriate use of the farm tractor and its related implements is necessary to boost productivity of land and labour, while reducing drudgery and improving timeliness of agricultural operations (FAO, 2008).

However, deterioration, that is, depreciation and functional deviation of these machinery commences immediately after they are manufactured which results in a reduction in their output (Bello, 2013). This is due to their exposure to environmental and working conditions. In an agricultural enterprise, this deterioration results in reductions in crop returns and consequently profit. This makes the correct operation and maintenance of farm machinery indispensable practices if their maximum capacities are to be realized (Ali, 2014). Proper maintenance carried out at the right time saves the farmer cost of replacement parts and repair, and reduces the incidence of unexpected breakdowns and down times (Sullivan *et al*., 2007). However, most operators in Ghana lack the appropriate skills to operate and maintain these machines effectively (Aikins and Kyere, 2012). For this reason, tractors in Ghana and other parts of Africa generally break down soon after their acquisition. Fonteh (2010) revealed that more than 20% of tractors imported into Mali were out of operation after a year due to poor maintenance. This study was therefore aimed at examining the expertise of tractor operators on tractor operation and maintenance and to assess their attitudes towards recommended maintenance practices.

2. MATERIALS AND METHODS

2.1 The Study Area

The survey was conducted at Ejura in the Ejura-Sekyedumasi District in the Ashanti Region of Ghana. Ejura is located within longitudes 1°5' W and 1°39' W and latitudes 7°9' N and 7°36' N at an altitude of about 228 m. The district is found within the transitional zones of the semi-deciduous

forest and Guinea Savannah zones of Ghana. The southern part of the district experiences bi-modal rainfall while the northern part experiences uni-modal rainfall pattern with the main rainy season being from April to November. Annual rainfall ranges between 1,200 mm and 1,500 mm. The land has flat and undulating topography and the soils in the district also have good water-holding capacity which make them very easy to work, making the place suitable for mechanised farming. Ejura therefore boasts of the highest population of farm tractors in Ghana. The soils range from sandy loam to clay and are suitable for growing crops such as maize, millet, groundnuts, cowpea, guinea corns, yams, cassava, garden-eggs and tomatoes (Taiwo and Kumi, 2015; Aikins and Kyere, 2012; Kemausuor *et al*., 2011).

2.2 Data Collection and Analyses

A questionnaire was prepared and used to collect data from 101 tractor operators at Ejura on their personal information, their expertise in tractor operation and maintenance, types of tractors and what they are used for, their general maintenance practices, lubrication and greasing and maintenance of the engine and its systems. The questionnaire was administered in March, 2015. Data collected were summarised and analysed using the Statistical Package for Social Scientists (SPSS) and results are displayed using descriptive charts and frequency tables.

3. RESULTS AND DISCUSSION

3.1 Personal Information

Responses to the questionnaire indicate that all tractor operators at Ejura are males. As shown in Table 1, 4% of the tractor operators were below 20 years of age. 9.9% of them were between 20 and 29 years, 45.5% were between 30 and 39 years, 23.8% of them were within the age range of 40-49 and 16.8% were 50 years and above. In all, 83.2% of the operators were below 50 years of age indicating considerable involvement of the youth in tractor operation at Ejura.

Table 1. Age of tractor operators

Age (Years)	Frequency	Percentage
Below 20	4	4.0
From 20-29	10	9.9
From 30-39	46	45.5
From 40-49	24	23.8
50 and above	17	16.8
Total	101	100.0

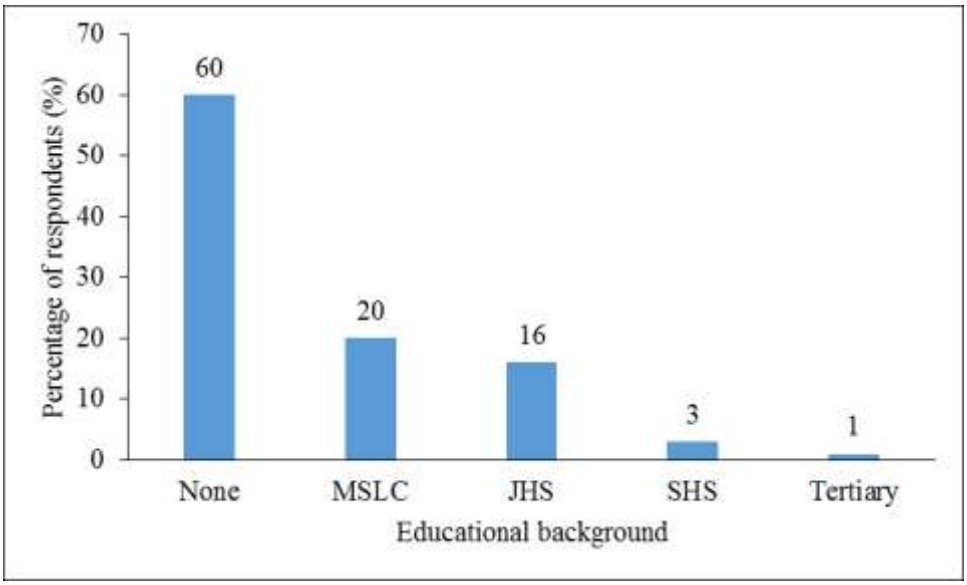

Figure 1. Educational background of tractor operators

Figure 1 also shows the educational background of tractor operators at Ejura. Those who have no formal education constitute 60% of the respondents. About 26% of the respondents have only basic education, that is, Junior High School (JHS) leavers and Middle School Leaving Certificate (MSLC) holders while 3% are Senior High School (SHS) graduates and 1% have up to tertiary level education. Education is necessity if one is to operate and maintain a tractor effectively since it will enable the tractor operator to read the operators' manual and understand how the tractor is used. Majority of these operators having no formal education implies they do not have the ability to read and understand the operators' manual which impairs their effectiveness in undertaking recommended operation and maintenance practices putting themselves and the tractor at risk (Aikins and Kyere, 2012, Adjei *et al.*, 2003).

3.2 Expertise of Tractor Operators in Operation and Maintenance

3.2.1 Training in tractor operation

Figure 2 shows how the tractor operators had their training in tractor operation. Responses from the interview show that 62% had their training through apprenticeship under older operators, 33% through operator training programmes organised by tractor operators' associations and 5% through an association of mechanics who are as well able to operate tractors. These associations have been encouraged by the government to help equip tractor owners and operators with knowledge in tractor operation and maintenance. The low level of education of tractor operators at Ejura as indicated in Figure 1 could be attributed to an early engagement of the youth in tractor operation through apprenticeship, which could be a discouraging factor to formal education. The method of apprenticeship training in tractor operation depicted in Figure 2 is suggestive of this observation.

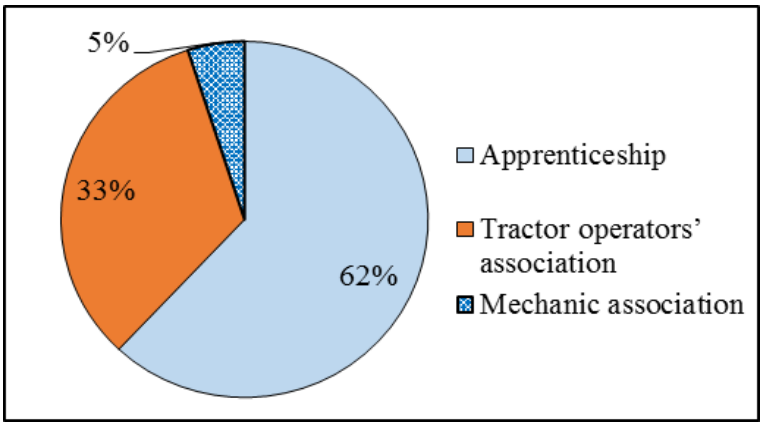

Figure 2. Training in tractor operation

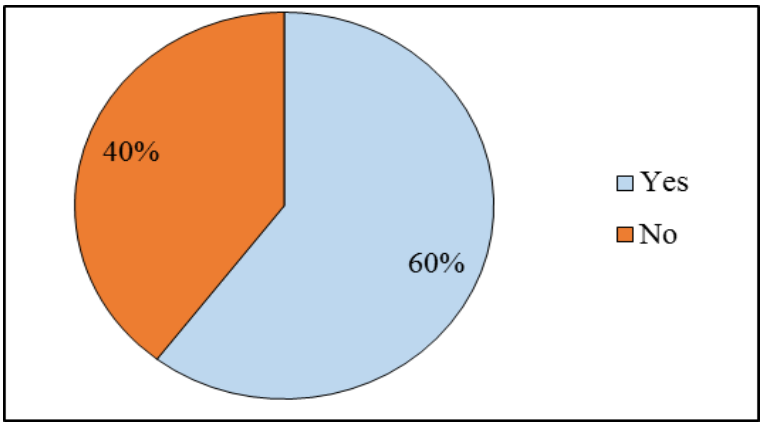

Figure 3. Training in tractor maintenance

3.2.2 Training in tractor maintenance

It can be seen from Figure 3 that 60% of the operators interviewed have had some form of training in tractor maintenance. However, about 40% did not have any form of training in tractor maintenance. Training in maintenance enables the tractor operator to effectively maintain his tractor which in turn increases the lifespan of the tractor (Adjei *et al.*, 2003).

3.3 Tractors and Their Uses

3.3.1 Make of farm tractors

Responses from the tractor operators interviewed show that the most common make of tractor found at Ejura is Massey Ferguson, representing 75.2% of tractors used at Ejura, as shown in Table 2. This confirms the finding of Aikins and Kyere (2012) which indicated that the most common tractor make used at Ejura was Massey Ferguson.

Table 2. Tractor makes

Tractor make	Frequency	Percentage (%)
Massey Ferguson	76	75.2
Ford	19	18.8
Farmtrac	1	1.0
Mahindra	3	3.0
Landini	2	2.0
Total	101	100.0

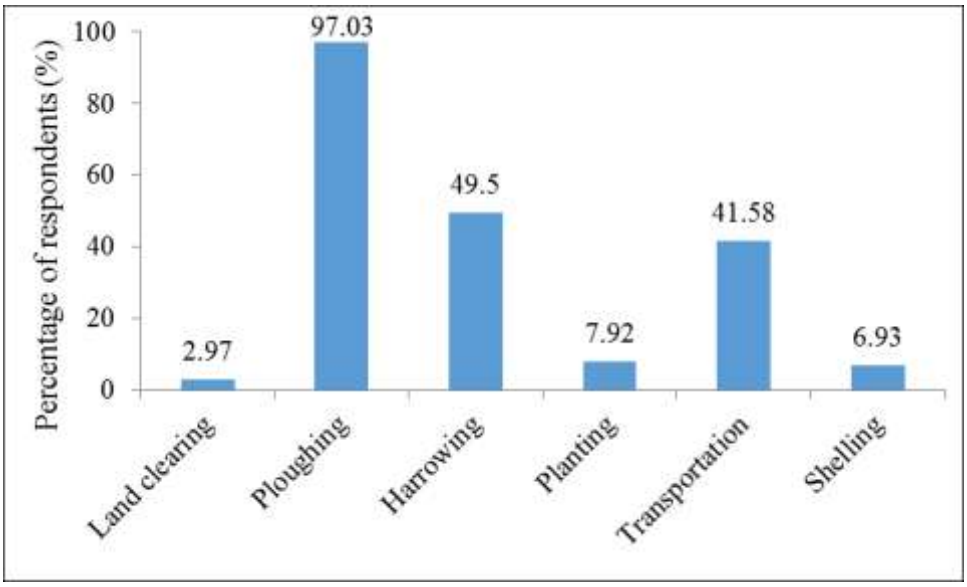

Figure 4. Uses of tractors at Ejura

3.3.2 Uses of tractors at Ejura

Figure 4 depicts the tasks operators at Ejura use their tractors to perform. About 3% use their tractors in land clearing operations, 97% use theirs for ploughing, 49.5% use theirs for harrowing, 7.9% use theirs for planting, 41.6% also use theirs for transportation purposes and 6.9% use theirs for shelling. How often a tractor should be maintained or serviced also depends on the kind of tasks it is used to perform. Almost all the operators use their tractors, among other operations, for land preparation such as ploughing and harrowing. Generally, however, land preparation is characterised by high draught requirement which exposes tractor parts and implements to higher levels of stress. Thus, the tractors need to be adequately maintained in order to reduce their rate of deterioration and ensure longevity (Sims and Kienzle, 2006; Paman *et al*., 2012).

Table 3. Responses on the possession of and adherence to operators' manual

Response	**Possession of operators' manual**		**Adherence to operators' manual**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Yes	25	24.8	20	80
No	76	75.2	5	20

3.3.3 Possession of and adherence to tractor operators' manual

Table 3 displays the numbers of tractor operators who possess operators' manual and the number that adhere to its recommendations. Just about 25% have operators' manual. Eighty percent out of this 25% adhere to the manual. This means that only 20% of those interviewed adhere to tractor operators' manual. This low percentage of adherence to manual could be attributable to the low level of education depicted in Figure 1 and confirms earlier findings by Aikins and Kyere (2012).

The tractor operators' manual is a very important document which enables an adherent operator to gain proficiency in tractor operation, develop safe operation practices and evaluate his techniques periodically to eliminate unsafe habits (Aikins and Kyere, 2012). Not adhering to the operators' manual can cause serious hazards resulting in fatal accidents and unexpected breakdowns (Anin, 2014).

3.3.4 Condition of hour metre

Table 4 presents responses on the condition of the hour metres of the tractors of the operators interviewed. Only 21.8% of the respondents have their hour metres in working condition. This shows that they do not see the importance of the hour metre and so do not make any decisions based on its readings. The hour metre records the hours the engine runs. It helps one to know when to check the inflation and conditions of tyres, tighten loose bolts and nuts, clean air filters and also change the engine oil. When one does not have the hour metre in working condition, it becomes difficult to accurately tell when to service or maintain certain parts of the tractor. This could also be a contributing factor to the low level of adherence to operators' manual presented in Table 3 This difficulty to determine the time for maintaining certain parts can lead to the deterioration of those parts, eventually resulting in breakdown (Bello, 2013).

Table 4. Condition of hour metre

Condition of hour metre	**Frequency**	**Percentage**
Working	22	21.8
Not working	79	78.2
Total	101	100.0

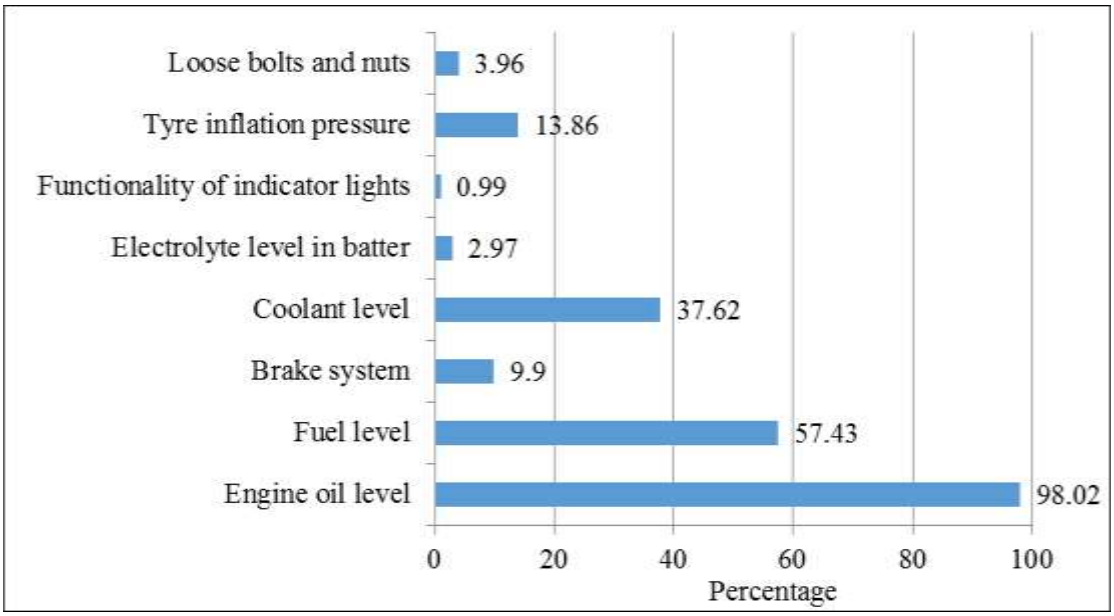

Figure 5. Responses on daily checks carried out by tractor operators

3.4 Maintenance Practices

3.4.1 Daily checks

Figure 5 shows the daily checks performed by the tractor operators that took part in the survey. Approximately 4% of the tractor operators check for loose bolts and nuts daily. About 14% check their tyre inflation pressure. Almost 1% check the functionality of their indicator lights, 3% check the electrolyte level of their batteries, about 38% check their coolant level, 10% check their brake system, 57% check their fuel tank level and approximately 98% check their engine oil level.

Generally, the chart shows that the operators are mindful of lubrication practices such as oil change. These practices help to keep the tractor in good condition. For instance, regular tightening of loose bolts and nuts will help prevent any loose part of the tractor from coming off while in operation. Checking of tyre inflation pressure, electrolyte level in the battery or fuel tank level can also help protect the tractor against unforeseen breakdowns on the farm and project the soil from excessive compaction (Bello, 2013; Harshman *et al*., 2004).

3.4.2 Record keeping

Table 5, shows the percentage of tractor operators who keep records and those who do not. It could be seen that only 20.8% of them keep records on the maintenance of their tractor, and this may be attributed to the low level of education as shown in Figure 1. Record keeping enables an operator to know which parts of the tractor was last serviced and which parts need servicing. It is upon this evidence that decisions are made for future actions (Clifton, 1982; Petrov and Bisnovaty, 1986).

Table 5. Records keeping

Record keeping	Frequency	Percentage
Yes	21	20.8
No	80	79.2
Total	101	100.0

3.4.3 Washing/Cleaning of the tractor

Figure 6 illustrates how frequently tractor operators at Ejura wash or clean their tractors. It can be seen that a sizable majority (86%) prefer to wash their tractors once a week, while 9% wash theirs more frequently. About 4% of the operators wash their tractors once every two weeks and the other 1% wash theirs only when they become dirty.Regular cleaning or washing of the tractor is very important because it will enable the tractor to last longer. Leaving soil and plant materials to decay on tractor parts causes corrosion of such parts. Also, oily steps and dirty safety decals on the tractor expose the operator to danger (Jarrett, 1995; University of Florida, 1998; Utah State University Cooperative Extension, 1995). Since about 95% of the tractor operators wash their tractors at least once in a week, it shows that they are generally mindful of the cleanliness of their tractors.

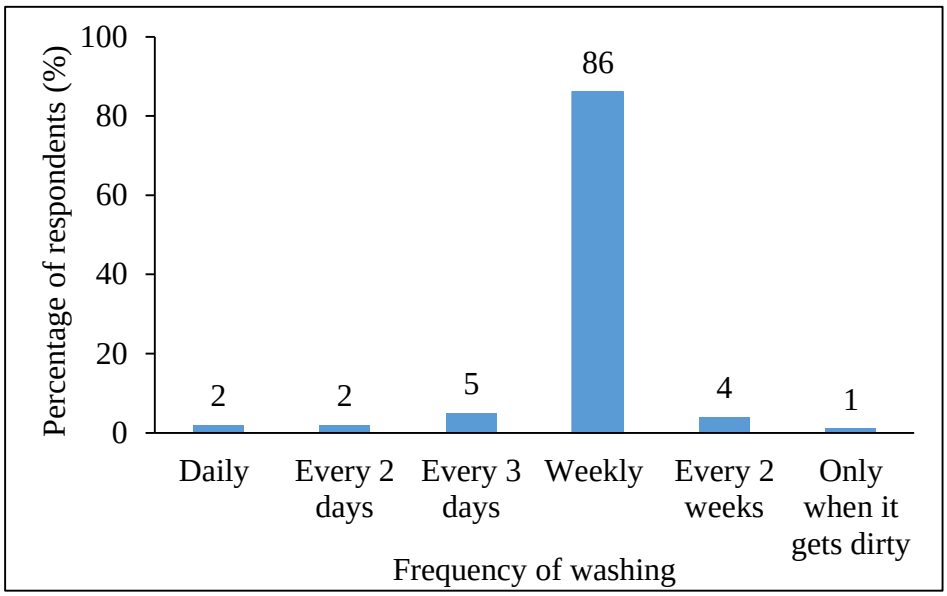

Figure 6. Washing of tractor

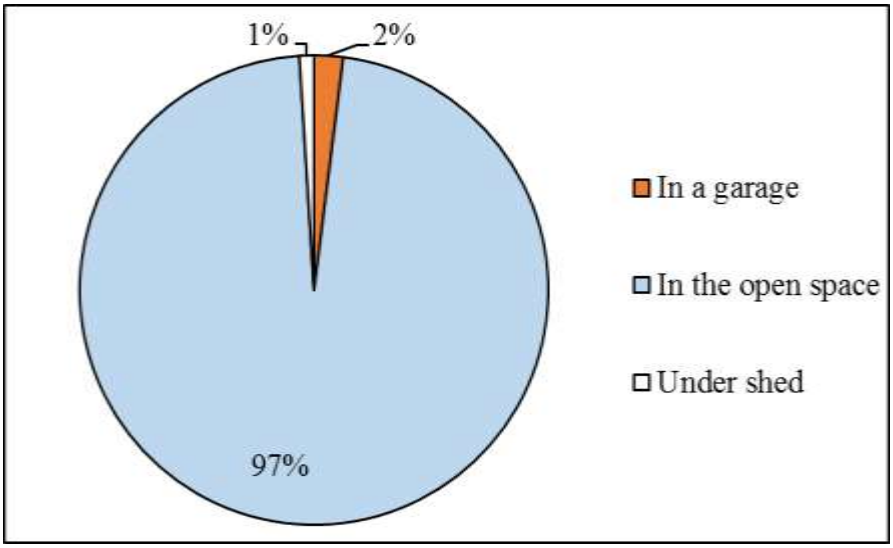

Figure 7. Tractor housing

3.4.4 Tractor housing

Figure 7 shows where tractors are kept after each day's work. Only 2% keep their tractors in a garage. 1% keep theirs under a shed but the majority which is 97% leave their tractors in the open space. Leaving the tractor in the open space will expose it to harsh environmental conditions such as wind and rain which will lead to rusting. Provision of shelter for the tractor will therefore protect it from theft and environmental conditions which will result in longer life and improved appearance (Aikins and Kyere, 2012; North Central Regional Farm Structures Coordinating Committee, Subcommittee on Machinery Storage and Farm Shops, 1952).

3.5 Lubrication and Greasing of Body Parts

3.5.1 Condition of oil pressure gauge

As shown in Figure 8, 85% of the tractor operators have their oil pressure gauge in working condition whereas the remaining 15% do not. The oil pressure gauge indicates the oil pressure inside the engine. It determines when the tractor needs a top up of engine oil. 85% of the operators having their oil pressure gauge in working condition means majority of them see the importance of lubrication. Lubricating moving parts of the engine protects it from friction, wear and excessive heating (Bello, 2013).

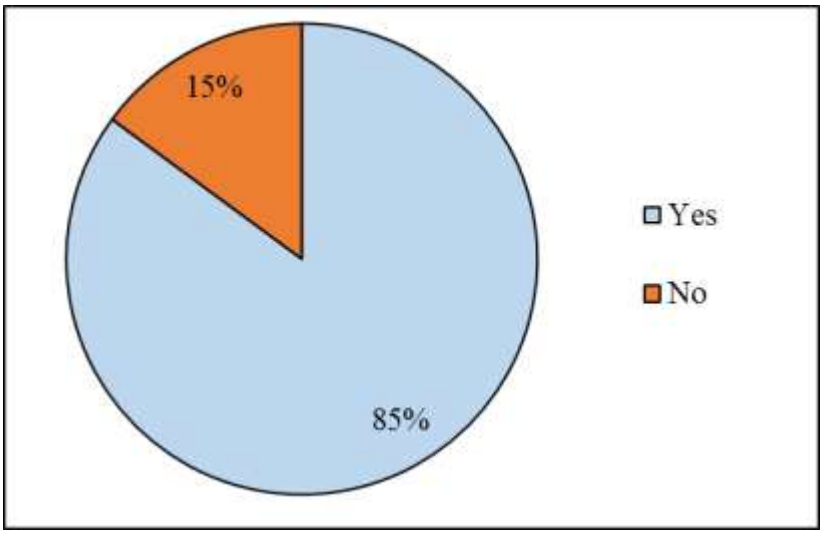

Figure 8. Working condition of oil pressure gauge

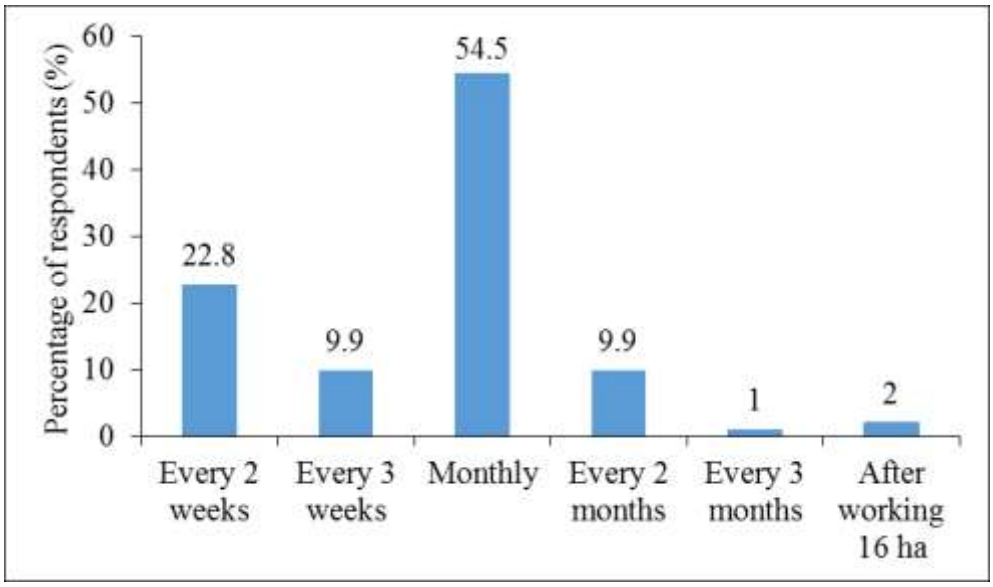

Figure 9. Frequency of changing engine oil

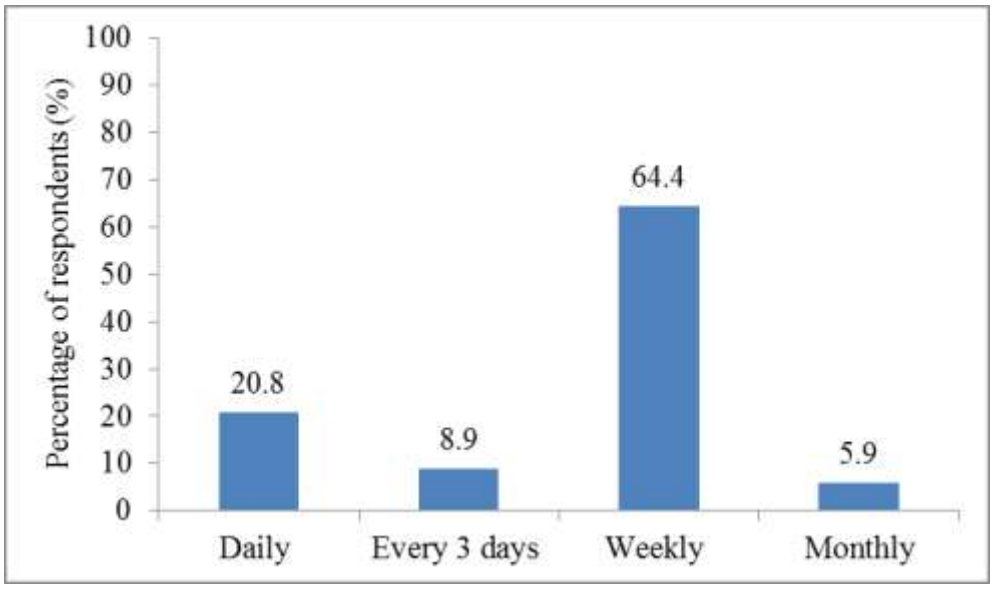

Figure 10. Frequency of greasing of tractor body parts

3.5.2 Frequency of changing engine oil and greasing

Figure 9 shows responses on how often the tractor operators change their engine oil. Approximately 23% change their engine oil once in every 2 weeks. 10% change theirs once in every 3 weeks, about 55% change theirs monthly, 10% also change theirs once in every 2 months, about 2% change theirs within every 3 months and 3% change theirs after working 16 hectares. This shows that tractor operators at Ejura generally do not base their oil use period and oil change on the number of hours the engine is run. This buttresses the observation that about only 22% of the operators have their hour metres in operating condition.

Figure 10 shows how frequently the tractor operators grease their tractor body parts. About 20.8% grease their tractors daily, about 8.9% grease theirs once in every 3 days, 64.4% grease theirs weekly and 5.9% grease theirs monthly. This shows that the tractor operators are mindful of lubrication. Lubrication is very necessary since it reduces friction and enables the moving parts of the tractor to function smoothly to reduce wear and heat generation.

3.6 Engine Systems

3.6.1 Overhauling

It could be seen in Table 6 that 95% of the tractor operators that took part in the survey have performed an overhaul of their tractors' engines while 5% have never performed an overhaul of their tractor engine yet. Most perform an overhaul once in every two years and usually as a result of the wearing off of their piston rings. The low level of adherence to maintenance manual could also be a course for that. Overhauling is a popular way of maintaining tractor engines and ensuring a problem free operation (Bello, 2013).

Table 6. Overhauling

Overhauling	Frequency	Percentage
Yes	96	95.0
No	5	5.0
Total	101	100.0

3.6.2 Changing of fuel filter

Figure 11 presents how often the tractor operators change their fuel filters. About 18.8% change theirs once in every 3 weeks, 51.5% change theirs monthly, 11.9% change theirs once in every 2 months and about 17.8% change theirs after changing the engine oil. The fuel filter is responsible for the removal of impurities from the fuel. Unfiltered fuel may contain several kinds of contamination such as dust particles, sediments, wax and rust caused by moisture in a steel tank. If these substances are not removed, they will cause rapid blockage and failure of the fuel pump and injectors. Fuel filters also help improve engine performance in the sense that the fewer contaminants there are in the fuel, the cleaner and more efficient the fuel combustion (Bello, 2013; Cummins Filtration Inc., 2010).

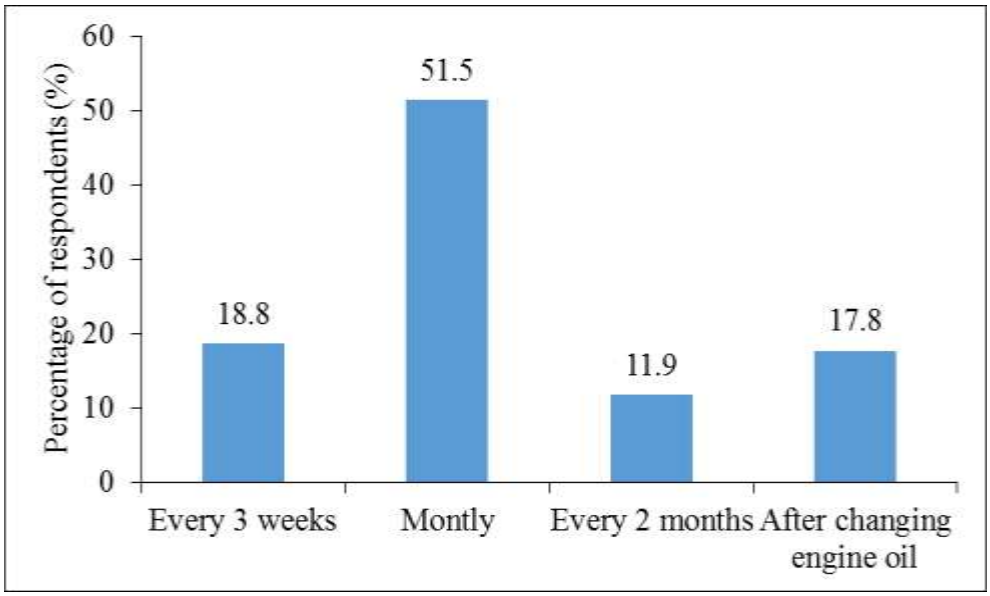

Figure 11. Changing of fuel filter

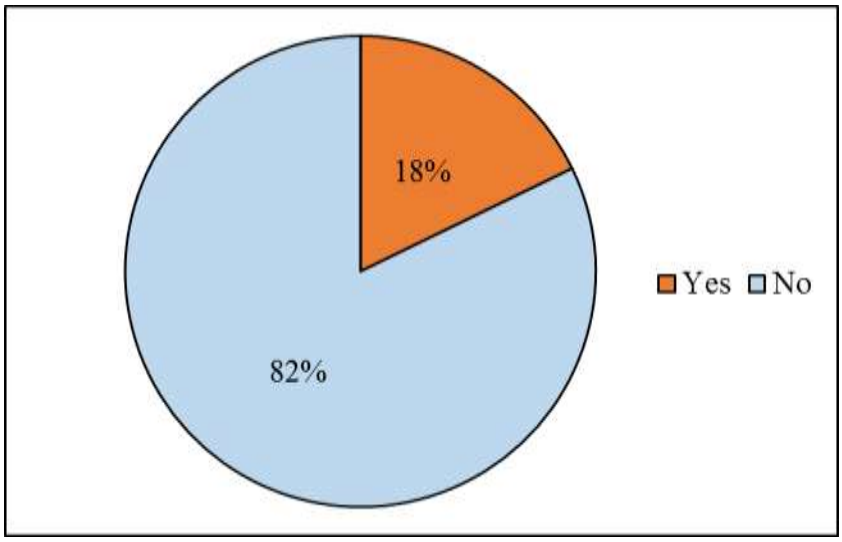

Figure 12. Working condition of thermostat

3.6.3 Cooling system: Condition of thermostat

Figure 12 represents responses of tractor operators on the condition of their engines' thermostats. Most of the operators, that is 82%, have removed their thermostats from their tractors. Only 18% have theirs in working condition. This is due to a general perception that thermostats are not useful in tropical areas of the world which implies the operators do not appreciate the fact that thermostats regulate the temperature of an engine and protects it from overheating. The thermostat is however useful as it ensures a quick warm-up of engines to vaporise the combustion water, which can otherwise react with some sulphur impurities in the fuel to form sulphuric acid and corrode the inner parts of the engine.

3.6.4 Electrical system: Cleaning of battery cables and terminals

Figure 13 depicts how often the tractor operators interviewed clean their battery cables and terminals. About 98% of them clean their battery cables and terminals while the remaining 2% do not. Regular cleaning of battery cables and terminals will help prevent hard starting of the engine due to accumulation of dirt or corrosion (Bello, 2013; Paterson, 2009).

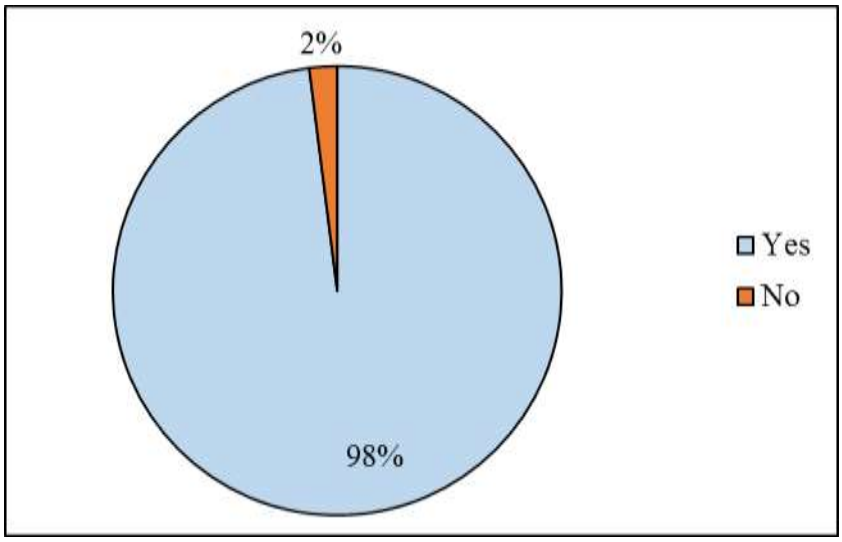

Figure 13. Cleaning of battery cables and terminals

4. CONCLUSIONS

Majority of tractor operators at Ejura have no formal education which implies that they do not have the ability to read and understand the operators' manual which impairs their effectiveness in undertaking recommended operation practices putting themselves and their tractors at risk. Most of these operators had their training in tractor operation through apprenticeship which means they have not been trained formally hence lack certain knowledge that will enable them to effectively operate and maintain the tractor. Almost all the operators use their tractors, among other operations, for tillage purposes such as ploughing which exposes tractor parts and implements to higher levels of stress since tillage operations are laborious.

Generally, it could be deduced that the operators are mindful of lubrication practices such as oil change and greasing, and the general cleanliness of their tractors and their components such as battery cables and terminals. However, only few of them possess and adhere to manufacturer's maintenance instructions. In addition, about 78% of the tractor operators at Ejura do not have their hour metres operational because they do not see the importance of the hour metre and hence do not make any decisions based on its readings. These observations imply that the operators' attitudes toward recommended maintenance operations are not appropriate.

The results also show that 97% of the tractor operators interviewed leave their tractors in the open space which exposes the tractors to environmental conditions such as wind and rainfall. This eventually leads to rusting of the tractor body parts. Also, 98% of the operators indicated they have uninstalled the thermostats on their engines, exposing the engine to the danger of damage through overheating and corrosion.

5. ACKNOWLEDGMENTS

The authors wish to express to express sincere gratitude to Mr. Boakye, an Extension Officer at the Ministry of Food and Agriculture, Ejura in the Ashanti Region of Ghana for facilitating the collection of data from the tractor operators.

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Identifying Gender from Facial Parts Using Support Vector Machine Classifier

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Abstract

Gender classification can be stated as inferring female or male from a collection of facial images. There exist different methods for gender classification, such as gait, iris, hand shape and hair, it is probably better way to find out gender based on facial features. In this paper SVM basic kernel function has been employed firstly to detect and classify the human gender Image into two labels i.e. (1) male and (2) female. The gender classifier achieves over 96% accuracy.

Keywords*:* Machine Learning; Support Vector Machine; Kernel; Cross Validation; Histogram Equalization.

INTRODUCTION

Machine Learning can be divided into (1) Supervised Learning in which case the target output is explicitly specified and (2) Unsupervised Learning where the training data comprises of a set of input vectors with no corresponding target values.
Support Vector Machine is one such Supervised Learning Model which has its own learning algorithms to analyses data and perform data classification/regression while eluding the over fitting issue. [1] SVM with its variety of similarity functions termed as Kernel Functions read inputs and predict the similarity between them. A kernel function is performed in the input space over a high dimensional feature space.

A linearly separable problem can be effortlessly classified into distinct groups by a separating hyper plane. Nevertheless, the role of a Kernel Function is realized evidently when the SVM classifier is implemented on inseparable data. For non- linear data, the kernel functions are used to non- linearly map the input data to a high-dimensional space. The new mapping can then be linearly separated [2].

Thus the principle idea behind our endeavor is to appraise the performance of SVM basic kernel functions which has been employed to detect and classify the human gender into (1) male and (2) female. These functions read as input the feature(s) of human facial image(s). The proposed algorithm is then executed on the elementary features of a human facial image i.e. eyes, nose, lips and their all possible combinations. Finally based on the accuracy percentage of the computed result the admissible outcome of the Kernel Functions has been realized.

Kernel Overview

The primitive Kernel functions of the Support Vector Machine Classifier are (1) Linear Kernel. (2) Gaussian-RBF Kernel. (3) Polynomial Kernel. (4) Sigmoid Kernel. Each kernel is associated with parameter(s) with its own default values [3-4]. These parameters are appropriately tuned to evaluate the performance of the kernel function in predicting the accuracy percentage of the tested results. It leads to the generation of a hyper plane which maximizes the margin and better generalization is achieved. Consequently, the points nearest to the hyper plane is assigned positive weight within the higher-dimensional feature space. These points are referred to as support vectors.

LITERATURE REVIEW

In the year 1992, Boser, Guyon, and Vapnik in COLT-92 first acquainted Support Vector Machine as a set of interrelated supervised learning techniques incorporated into a family of generalized linear classifiers which can be applied to a data set for classification and regression [5-7], The classifier can be applied on variety of data set including text, image, audio, video to achieve a desired level of classification. One such renowned application of SVM Classifier is in the field of Human Gender Detection and its Classification. The connotation of Gender Recognition was first identified in the field of research and development at the inception of 1990s. Similarly, Golomb et al. [8] used multi - layer neural network to recreate a solution to the gender classification issue. Nearly 900 manually aligned facial images were compressed into 40 images on which the classification was performed. An error rate of 8.1 was

reported. The research work was based on human facial features as the primary components on which the gender classification algorithm was implemented.

Shobeirinejad and Gao [8] also proposed an Interlaced Derivative Pattern (IDP) to extract facial features. The IDP image is a four-channel derivative image representation technique where images are viewed from different angles which includes 0°, 45°, 90°, and 135°. This method too emphasizes on the extraction of distinct facial features and convey crucial information about gender identification. Similar task was also accomplished by LU et al. [9-10]. In their experiment CAS-PEAL database was used. 480 × 360 Grey scale images were transformed to normalized whole facial image and normalized internal facial image. Experiments were performed based on a technique on seven facial regions of varying resolution. In order to improve the overall performance this method performed fusion of multiple facial regions. With regard to all the previous work, in the year 2015, an allied task of Human Gender Classification was attained by Mrs. Sayantani Ghosh &Prof. Samir Kumar Bandyopadhyay. They used the 'lip' as the primary feature of the frontal facial image. Utilizing the aforesaid extracted feature, a similar experiment was percolated using multi class SVM to consummate the task of Age Detection and its classification into predefined class labels i.e. 'child', 'adult' and 'old'. [11]

In this paper, analogous to the preceding methodologies, a refined technique has been proffered. The dataset chosen for the examination of the proposed algorithm comprises of 100 JPEG frontal facial images which includes 50 males and 50 female images. The Region of Interest(ROI) principle is employed for the identification of the location of the feature(s) like eyes, nose, lips. The specified algorithm is then implemented on the dissociated feature(s) and their variety of combinations i.e. eye, nose lip, eyes nose, nose lip, eyes lip eyes, nose lip. An evaluation process computed the accuracy percentage of the resultant outcome for each input feature(s). The primitive objective of this procedure is to estimate the performance of the primary kernel functions i.e. Linear, Gaussian, and Polynomial kernel.

PROPOSED METHODOLOGY

This section emphasizes on the analysis of the proposed technique being adapted to attain the task of Gender Detection and its Classification using variety of combinations of human facial features. In addition, a metamorphic reasoning on the performance of the Kernel Functions in predicting the accuracy percentage of activated result has been accomplished.

Algorithm

Step 1: Input JPEG Image Set.
Step 2: Metamorphose individual image to grey scale version.
Step 3: Percolate histogram equalization on each grey scale image.
Step 4: Extract the primary features from the facial image.
Step 4.1: for each extracted feature image perform a sequential execution of the below specified steps
Step 4.1.1: Reshape the extracted image from 2 D -1D.
Step 4.1.2: Generate a feature vector for each extracted feature image(s).
Step 4.1.3: Associate with each image i.e. for each row vector a class label. Assign +1 to female image and -1 to male image.
end
Step 5: Shuffle each row of Feature Vector.
Step 6: Cross- Validate the updated matrix and generate the train set and the test set.
Step 7: Select appropriate kernel with its parameter value(s) of the SVM classifier and train the appropriate known data set.
Step 8: Apply test method of SVM to test the unknown data set.
Step 9: Retrieve the final classified result.
Step 10: End.

Implementation

The implementation details of the above stated methodology are enlisted as follows:

- Software used- MATLAB routine of the libSVM 3.18 toolbox. [12]
- Input Set- An image set comprising 100 Jpeg frontal facial images (50 males and 50 females). Each image resized to dimension 128*115.
- Individual image pre-processed to remove unwanted components, enhance the image and improve the image contrast.
- The train set is executed to generate the train vector using the svmtrain () routine.[12]
- The class labels of the unknown data set are determined by invoking the svmclassify () routine. [12]

The extraction principle applied on facial images to extract its distinguishable features is the Region of Interest (ROI) principle. Some preprocessing steps are taken into account for the extraction in a better way. The steps followed in this principle are matriculated as follows.

- Select an appropriate window dimension based on the location of the facial feature of the human frontal facial image.

- The feature is then identified and extracted from the selected location using the imcrop () function.
- Each extracted image is resized to a one dimensional vector.
- Feature Vectors of the extracted feature/ feature pair i.e 'eyes', 'nose', 'lips', 'eyes nose', 'nose lips', 'eyes lips' are generated. With each row vector of the Feature Matrix class label of +1 is assigned for the female image and a class label -1 is assigned for the male image.

The diagrammatic Representation of the Feature Extraction Phase is illustrated in the following figures.

Fig 1: Original Gray Scale Image

Fig 2: Unveiled Region of Interest 1

Fig 2.1: Extracted Eyes Region

Fig 3: Unveiled Region of Interest 2

Fig 3.1: Extracted Nose Region

Fig 4: Unveiled Region of Interest3

Fig 4.1: Extracted Lip Region

In shuffling phase the individual row vector of the feature matrix is shuffled. The shuffled matrix is then subjected to the next level of processing i.e. cross validation. The main objective of shuffling is to obtain a cross validated result with improved precision. The following tables describes different phases involved for finding gender.

Table 1: ***Tabular Representation of the class labels of the original feature vector consisting of 100 chosen images where '1' represent the female gender and '0' represent the male gender.***

1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0				

Table 2: ***Tabular Representation of the Shuffled Matrix.***

0	0	0	1	1	0	1	0	0	0	1	0	1
1	0	0	1	1	1	0	0	1	1	1	0	1
0	1	0	0	1	0	1	1	1	1	1	0	0
1	1	1	1	1	0	1	1	0	1	1	1	0
1	0	0	0	0	1	0	0	1	1	1	0	1
1	1	0	0	0	0	0	1	1	0	1	1	0
1	0	0	1	0	0	0	0	0	1	1	1	0
1	0	0	0	0	0	0	1	1				

Cross Validation of the Shuffled Matrix is one of the key steps in Gender Recognition Algorithm. It resolves the issues like over fitting of images. Besides if the original data set is appropriately cross validated, it can be effortlessly divided into the train set and the test set. The size of the train set and the test set however depends on the degree of the cross validation technique. Like the 'hold out technique divides the original set into two equal sized sets, while the other techniques like '10 fold' cross validation and '5 fold 'cross validation dissociates the primitive data into 10 segments and 5 segments respectively. Each time one segment is tested to predict the class labels of the undetermined set after acquiring the result of the training of the remaining (n-1) segments.

Table 3: ***Tabular Representation of '10 fold 'Cross Validated Data Set. Here the train set comprises of the data with class label '1'which includes 90 instances while the test set comprises of the data with class labels '0'which includes 10 instances of the 100 prime data set.***

1	1	0	1	1	1	1	1	1	1	1	1	1
1	1	1	0	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	0	0
1	1	1	0	1	1	1	1	1	1	0	1	1
0	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	0	1	1	0
1	0	1	1	1	1	1	1	1				

The cross validated data are then trained using the svmtrain () function of the libSVM toolbox. [12] Finally, the trained result is subjected to the svmclassify () routine of the libSVM toolbox [12] which classifies the test set and predicts the class labels of the unknown set.

Table 4: ***Tabular Representation of the output class labels of the Tested Result***

0	1	1	0	0	1	1	1	0	0

Table 5: ***Tabular Representation of the actual class labels of the original Feature Vector***

0	1	1	0	0	1	1	1	0	0

EXPERIMENTAL RESULT

The program code of the above stated algorithm has been written using MATLAB version R2013a. On proper excerption of the key kernels available in SVM i.e. (1) Linear (2) RBF and (3) Polynomial. The graphical Analysis of the performance of different Kernels are presented in the following figures.

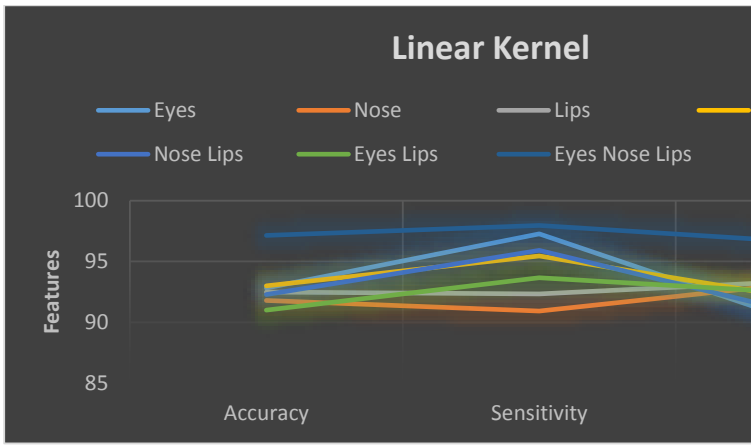

Fig 5: Graphical Analysis of the performance of Linear Kernel

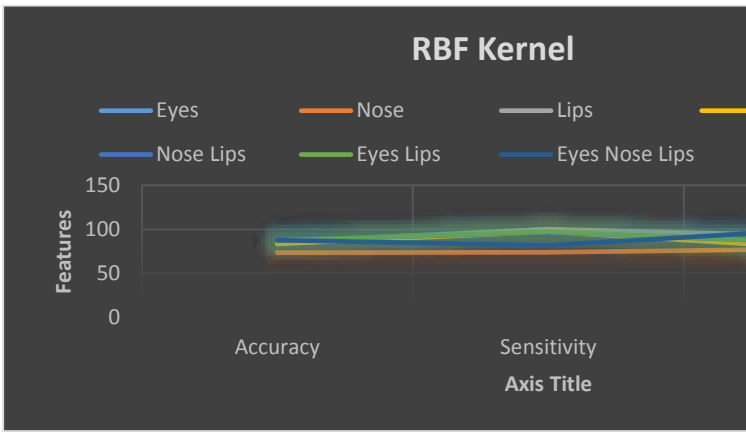

Fig 6: Graphical Analysis of the performance of RBF Kernel

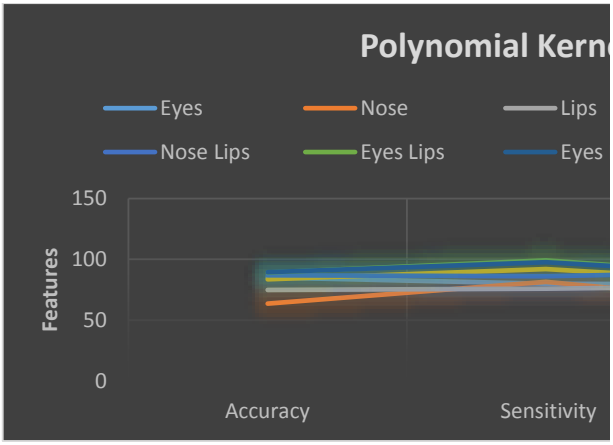

Fig 7: Graphical Analysis of the performance of Polynomial Kernel

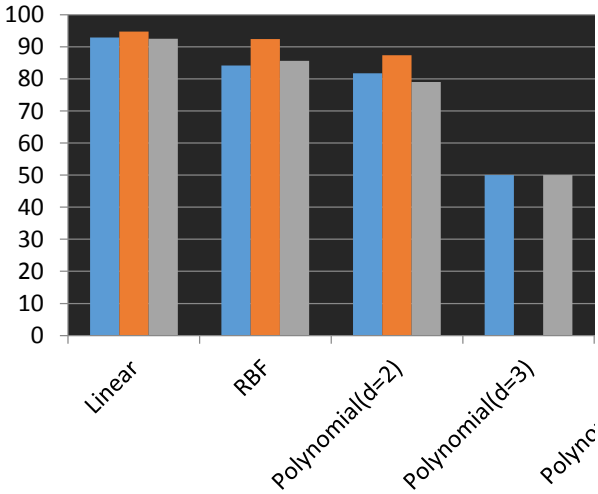

Fig 8: Graphical Representation of Comparative Analysis of Kernels Functions

CONCLUSION

The test results as stated in the previous sections characterize the performance of the kernel functions in the evaluation of Gender Classification based on the combination of features of Human Facial Image. With this paper we have endeavored to prolongate our previous task of Human Gender Classification. [11] In our experiment, the test results verified the behavior of a kernel on a given data set. The Linear Kernel yielded the best result when implemented on data set comprising of 100 Images linearly separated into 50 males and 50 female images compared to RBF and Polynomial Kernel. The Polynomial Kernel which is best suited for non-linear data set generated poor result for degree's=3' or 's=4'. Thus its degree was lowered to 'd=2' that led to the generation of favorable yet no so high result. However, the RBF kernel did not make a notable performance since firstly, the data set is inherently linearly separated and secondly the feature vector includes an increased feature count over input instances. Thus with an idea of achieving upgraded performance of the proposed methodology, the data set shall be increased with more instances.

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Congestion Control in Wireless Sensor Networks- An overview of Current Trends

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Abstract: In WSN congestion occurs when traffic load exceeds the capacity available at any point in a network. Congestion acts an important role in degrading the performance of the network or failure of the network. So it is essential to detect and control the congestion in the entire WSN. Thus one can improve the performance of the network. Different factors are involved in the congestion; the main factor is buffer over flow, packet loss, lowers network throughput and energy wastage. To address this challenge this is essential for a distributed algorithm that mitigate congestion and allocate appropriate source rate to a sink node for wireless sensor network. This paper gives some ideas how to control and manage the congestion in a wireless sensor network.

Keywords: Wireless Sensor Networks, Congestion Control, Congestion Detection and Mitigation

I. INTRODUCTION

The WSN is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical environmental conditions, such as temperature, sound, vibration, pressure motion or pollutants, at different locations [1]. WSN has significantly different communication constraints. The devices in such type of network are deployed in a huge numbers; they need the ability to assist each other to communicate data to a centralized collection point which is called a sink or a base station. The smallest devices are composed of a sensing unit, a radio, a processor integration of the sensor and having a power unit. The devices are capable of monitoring of a wide variety conditions such that temperature, humidity, soil makeup, pressure, vehicular movement, lighting conditions and noise levels, etc.

A typical example of pervasive computing applications is WSN, which has a broad range of applications such as military reconnaissance, environment monitoring, disaster relief and agriculture. The foremost aim of this type of network is to improve its life time and energy efficiency, load balancing packet transfer from sink to network as sensor of network is to conserve battery power. In WSN the powered mainly consumed for three purposes: data transmission, signal processing and hardware operation. With the rapid development and increasingly mature technology of MEMS (Micro Electro Mechanism System), wireless communications and modern networks merge into wireless sensor networks (WSN) [2]. It has created various innovative sensor network applications in near future. Today's sensor nodes are capable of sensing more than one parameter with the aid of multiple sensor boards mounted on a single radio board [3]. It is more efficient, reliable and cost effective to use multi sensing unit instead of multiple nodes with multiple functionality.

Congestion is a problem in wireless sensor networks. Some techniques are used to reduce the congestion in WSN. Fusion's Techniques mitigate congestion, queue occupancy detects congestion, hop-by-hop flow control improves the efficiency of the network and source rate limiting as will improves the fairness. Fusion improves efficiency by 3 times and eliminates starvation [4]. Different types of data generated by the sensors have various priorities. Hence it is necessary to ensure desired transmission rate for each type of data based on the given priority to meet the demands of the base stations. In such a network, the sensor nodes could in fact generate simple periodic events to unpredictable bursts of messages. Congestion occurs even more likely when concurrent data transmissions over different ratio links interact with each other or when the reporting rate to the base station increases. When the number of nodes in the entire network increases the congestion might occur frequently [5]. A typical model of Wireless sensor network is shown in Figure 1 [6].

The rest of the paper is organized as follows. In Section II, causes of congestion are discussed. In Section III, types of

Congestion are elaborated followed by congestion control mechanism in Section IV. Finally, the paper in Concluded in section V.

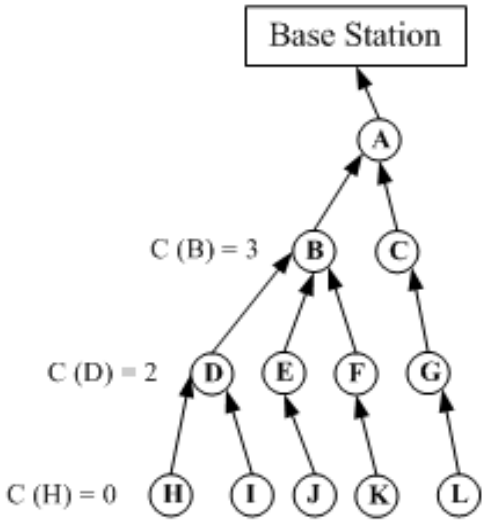

Figure 1: Wireless Sensor Network Model.

II. CAUSES OF CONGESTION

When the data traffic of source nodes nearby sink grows, the offered lead exceeds capacity available and the network becomes congested. The congestion has buffer overflow, channel contention, interference, packet collisions and many to one flow nature. When the number of packets is more than the available space of buffer the buffer over flow occurs. Contention occurs between the different flow and different packets of a flow. Interference occurs along multiple path of a network among the nodes nearby due to simultaneous transmission [7]. Packet collisions lead to packet drops. Many to one nature of data communication between many sources and sinks result in bottleneck around sink [15-33]. Congestion results to degrade the channel quality, packets loss per unit time.

III. TYPES OF CONGESTION IN WSNs.

Congestion can be classified into two major categories.

1. Location based.
   a. **Location based congestion** includes, Source congestion and sink congestion.
   b. **Source congestion:** The event occurred is detected by all the sensor nodes in the special, these nodes are source nodes for next transmission. If the node's radi ranges is greater the sensing range will also be greater. If the sources fall in each other's radio range, the can communicate with each other. If all the source nodes, start sending packets to the same time to the sink at high rates, then a hot spot zone will be formed around the sources ant within this hot sport a large number of packet will be dropped.

2. **Sink congestion:** When the sensors observe an event at a high date rete, sink nodes and the nodes around them will sense a high traffic volume. If a hot spot occurs around the sink, the packet will be lost inside the congested area near the sink, and dropping of a packet around the sink needs recovery of packets by some means.

3. **Forwarder Congestion:** The date sensed must be reached to the destination by source and sink nodes. Data in a sensor network has multiple paths and these paths are interconnected with each other. The area surrounded the intersection will possible become a hot spot for congestion.

   a. **Causes of Packet loss**:

It has mainly two types (Buffer over flow and link collision)

1. **Buffer over flow** (Node level congestion). When the packet arrival rate exceeds the packet service rate this type of congestion occurs. In most cases this is occur in sensor nodes near to sink node.

2. **Link collision** (Channel congestion/ Link level congestion): For WSNs where wireless channels are shared by several nodes using CSMA like Protocols [34-42], collision could occur when multiple active sensor nodes try to seize the channel at the same time. Link level congestion increases packet service time, and decreases both link utilization and overall throughput and wastes energy at the sensor nodes [8].

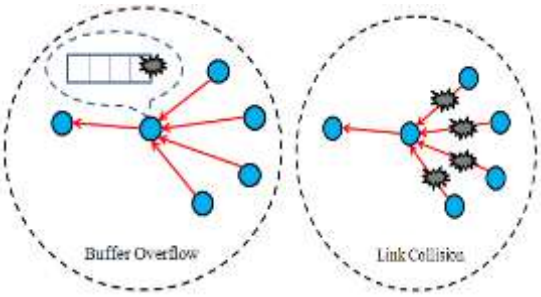

Figure 2: Congestion in WSNs [9]

IV. CONGESTION CONTROL MECHANISM

Two main types of congestion in a WSN are buffer congestions and channel collision. Channel Collision can be overcome using Data Link Layers' mechanisms: CSMA (Carrier Sense Multiple Access), FDMS (Frequent Division Multiple Access). Through these mechanisms the medium can be shared with frequent division FDMA, time division TDNA and sampling medium on the existence of the transmission of some other node CSMA.[10]

V. SCHEMES OF CONGESTION CONTROL

Congestion control can be divided into two main categories: (1) Centralized Congestion Control Schemes, (2). Distributed Congestion Control Schemes.

a. Centralized Congestion Schemes:

This scheme is consist of routing protocols with congestion control. In this scheme a centralized approach is used as all the actions for controlling the congestion is undertaken by base station / sink node. All the activities such as congestion detection and avoidance are taken by the sink. Decision is always taken by the centralized node, the sink node applies the command and the decision is taken according to the centralized scheme. The sink/ base station periodically collects data from the sensor nodes, detects the possibility of congestion, and accordingly sends messages to the involved sensor to mitigate the congestion. **Table 1** has a summarized detailed discussion on some centralized congestion control schemes [11].

Table 1. Comparison of the existing centralized routing protocols with the congestion control.

S.No	Protocol	Operational Strategy	Congestion Detection Criteria	Priority Criteria	Packet Drop Priority	MAC
1	Directed diffusion	Routing with aggregation, distributed in nature	Buffer Overflow	No	No	CSMA
2	ESRT	Routing with congestion support, centralized in nature	Buffer Overflow	No	No	CSMA
3.	PSFQ	Routing with congestion support, centralized in nature	Buffer Overflow	No	No	CSMA
4	RCRT	Centralized congestion detection, rate adaptation, and rate allocation	Buffer Overflow	No	No	CSMA
5	I2MR	Routing aided by congestion control	Buffer Occupancy, and exponential weighted	NO	No	No

			moving averages for long term congestion detection			
6	TADR	Routing with congestion control	Buffer and Rate, hybrid scalar potential field	No	No	NA

b. Distributed Congestion Control Schemes.

The congestion in this case is distributed in nature. The congestion control is dispersed over the entire sensor field. The scattered deployment nature of sensor nodes results in the distribution of congestion control algorithm into various routines and sub routines across the wireless sensor network. These routines are executed by certain events in the sensor fields called stimulus and accordingly produce response. The result of one routine/subroutine may act as a stimulus to another subroutine. Table 2 summarizes the congestion detection criterion in Distributed congestion Control Scheme. [12]

Table 2: Mutual Comparison of existing distributed congestion control protocols.

S.No	Protocols	Operational strategy	Congestion detection criteria	Priority Criteria	Packet Drop Priority	MAC
1	CODA	Congestion Control	Single Buffer Occupancy congestion detection criteria	No	No	CSMA(VC)
2	ECODA	Congestion Control	Dual Buffer Occupancy	Yes	Yes	CSMA with AIMD
3	ECODA	Congestion Control	Buffer Occupancy, Incoming Flows	Probabilistic Algorithm		
4	DAIPaS	Congestion Control	Buffer Occupancy Channel Interference	NO	NO	NA
5	ADCC	Congestion Control	Transient Buffer Monitoring Using EWMA	NO	NO	NA
6	LPCC	Congestion Control	Transient Buffer Monitoring using EWMA	NO	NO	NA
7	PCCP	Congestion Control	Buffer monitoring, Packet inter arrival time and service reflecting congestion	NO	No	NA
8	DPCC	Congestion control	Buffer occupancy and traffic flow	NO	NO	CSMA, Back off interval
9	LACAS	Congestion control	Learning automata	Pre defined rules	Pre defined rules	NA
10	Fusion	Flow control, rate limiting,	Buffer and rate	NA	NA	CSMA with RTS/CTS

		and prioritized MAC				
11	Buffer based congestion avoidance	Congestion control	Buffer occupancy	NA	NA	CSMA with implicit ACKs and TDMA with fix scheduling

VI. CONGESTION CONTROL MECHANISMS IN WSNS.

It has mainly three phases (Detection, Notification & Rate adjustment)

a) Congestion Detection:

In WSN congestion can be detected by several ways like, buffer occupancy, channel sampling and packet service rate and scheduling rate.

b) Congestion Notification:

When the congestion is detected the entire network is informed about it in one of the ways below:

a. Explicit congestion notification
b. Implicit congestion notification

c) Congestion control approaches:

(Resource management and Traffic control)

Resource Management: To mitigate the congestion the network resource management tries to extend network resources. In wireless networks, power control and multiple radio interfaces can be used to increase bandwidth and weaken congestion.

Traffic Management: Have two methods for traffic control in WSN.

A. The hop-by-hop congestion control: It has faster response, it is usually difficult to adjust the packet forwarding rate at intermediate nodes mainly because packet forwarding rate is dependent of MAC protocol and could be variable.
B. The end-to-end congestion control: It imposes exactly the rate of adjustment at each source node and simplify the design at intermediate nodes, it results in slow response and relies highly on the round trip time (RTT) [14].

VII. CONCLUSION

WSNs experiences congestion, so it is required solution to control congestion. A lot of research and solutions are published to overcome the congestion problem. We made a survey on congestion control mechanisms for WSNs and underlined some suitable techniques and assumption to mitigate the congestion problem in the wireless sensor networks.

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A Survey on Agriculture Monitoring Using Wireless Sensor Network

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Abstract-Wireless sensor network is an autonomous network which consists of resource constraints sensor motes which are used to capture various events of interest such as temperature, humidity and pressure. These networks are used in many areas like agriculture monitoring, health care monitoring, forest fire monitoring, environmental monitoring etc. These networks are used to monitor various agriculture products or various parameters in agriculture such as the quality of fruits, vegetables, the amount of oxygen and nitrogen required. In this paper we aim to present the existence studies of wireless sensor networks which are used for agriculture monitoring. We will explain in details the advantages and dis advantages of the existing studies and we present our own analysis and conclusion.

Keywords: Wireless Sensor Network, Agriculture Monitoring, Sensor Node, Fertilizers

I. INTRODUCTION

Nowadays agriculture required technology to increase the production quality. The sensor field in agriculture may bring out the fundamental contribution to precision agriculture. The precision agriculture is defined as the method of applying the correct amount of input (water, fertilizer, nitrogen etc.) at the accurate location and at the accurate time to increase production and improve quality, while protecting the environment.

WSN is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions. Each node consists of processor, have a RF transceiver (Omni-directional antenna), have a power unit (e.g. AA batteries, quartz cells and solar cells) and accommodate various sensors. The nodes communicate wirelessly.

II. PROBLEM DEFINITION

Farmer experiences huge economic losses due to wrong prediction about weather and wrong irrigation method. When the Wireless Sensor Network is developed now it is very easy to apply them for increasing the quality and quantity of crops. Nowadays it is huge problem because of unawareness about the techniques methodologies and tools used and type of soil content, type of fertilizers to be added. Currently inquiry of soil to increase quantity of crop production is not utilized very much due to

the high price. As there is very big field for crop so the soil sample cannot be efficient to send to lab which will represent the whole land because whole land has different types of soil.

To use sensor motes it is computationally high in terms of energy. The achievement of sensor motes applications is based on consistent transmission of data packets among sensor motes. One of the major problems in WSN environments is the resource starvation problem. High energy is spent in data transmission from sensor nodes to the base station.

III. LITERATURE REVIEW

The suggested irrigation management system in [1] which was utilizing intelligent humidity sensor and low power SWT for facilitating irrigation management. The monitoring device used in this paper is laptop/computer. The proposed system in [2] determines the soil moisture and necessity of water to crop in order to supply just the right amount of water just enough to maintain moisture level. A microcontroller is used to control the operation along with relay switch and pump. The proposed system in [3] uses the sensor node that include JN5121 module, an IEEE 802.15.4/zigbee wireless microcontroller. GPRS gateway was used for long distance data transmission. The mobile unit was used as monitoring device.

The proposed system in [4], a study of zigbee based wireless sensor network in agriculture was carried out. This paper has reviewed few issues regarding zigbee in agriculture, i.e., how the factors like node spacing, antenna height, and density of leaves affects the signal strength. The energy efficient WSN for agriculture proposed in [5] uses the sensor node equipment with CC1110 system on chip with low power RF Tran's receiver and 8051 MCU from texas. A CC 1110 evaluation module plugged into smart RF04 evaluation board who's LCD and LED buttons are readily available for monitoring and control. The hardware allows radio transmission in multiple power levels and also allow user to change receiver sensitivity. The proposed system in [6] also

includes the camera nodes and cattle sensor network along with the soil moisture sensor.

The instrument in [7] [9] [10] is designed to monitor the soil temperature and humidity of agriculture environment. The tests were done to verify the reliability and accuracy of the temperature and humidity monitoring system. Two different sets of test were conducted i.e. in close room and open room environment [7] [11-22]. The position estimation of sensor nodes in WSN for precision agriculture generally include errors and it is concluded that the average value of localization error decreases with the signal propagation coefficient and proved that the robustness of NMDS (nonmetric multidimensional scaling) algorithm for bad environment [8] [23-29].

IV. PROPOSED WORK

Pakistan is one of the World's largest mangoes production country. Its requirement for water and fertilizer are equally high. Heat, humidity and sunlight plays important role in mangoes growth, vegetative growth and ripeness. Mangoes grow well in humid and hot weather. It requires humidity of 70% for more vegetative growth.it is clear that growth of mangoes crop is highly dependent on few climatic factors like air temperature, humidity, and soil temperature and soil moisture. So it is essential to monitor few climatic conditions for the better yield of mangoes.

This paper would take the opportunity to build a device that is able to monitor the humidity, temperature , and soil temperature and send it to a remote receiver which will be outside the field. The system represented in this paper consists of the microcontroller, base station, nodes, device control node and mobile phone. The WSN data collecting node is connected with temperature, soil moisture and humidity sensor. When these sensor nodes find an irregular or improper environment condition of the soil the nodes will send alarm signal to base station which will be encoded. Once the base station receives an alarm signal, it will send a SMS to farmer through the GSM module and GSM network immediately.

a) Sensor node

The sensor node is very important unit of the environmental monitoring information system; its task is to attain collection, perception, processing and wireless communication of environmental data.

A node consists of four basic components which are sensor, power unit, processor and radio transceiver. The sensor converts such measured physical quantities as temperature, humidity etc. into a voltage signal and digitizes it to produce digital output for processing. The processor with a microcontroller controls all of the functions of the sensor node and manages the communication protocols to carry out specific tasks [30-39]. Communication between the WSN node and the base station is provided by the Radio transceiver unit. And finally the power unit, which is the most essential component of a sensor node, supplies power to all of these units.

b) *Base station unit*

This unit is responsible for collecting the data from all the sensor nodes [40-49] and critically evaluates the data, if it finds an abnormal or unsuitable environment condition of the soil, the base station send a SMS to farmer through the GSM module and GSM network immediately.

V. CONCLUSION

The proposed system in this paper is designed by considering the requirement of a mangoes crop for Pakistan weather. The WSN in agriculture is new technology for information gaining and processing in mangoes field. It is more beneficial than the traditional agriculture techniques. This is low cost system where the recorded information is transmitted to remote location using a GSM network via a SMS. The farmer may use the received information to control the parameters. This kind of wireless detection and control improves the effectiveness and efficiency of resources used, which leads to the improved production. The drawback of system is its dependency on the GSM network.

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An Overview of 5G Wireless Cellular Technologies

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Abstract- 5G technology stands for fifth Generation Mobile technology. From generation 1G to 2G and from 3G to 5G this world has revolutionized by improvements of wireless network. This revolution brought up some drastic changes in our social life .This paper also focuses on all preceding generations of mobile communication along with fifth generation technology. Fifth generation network provide cost-effective broadband wireless connectivity (very high speed), which will be probably 1gigbit per second Speed. The paper throws light on network architecture of fifth generation technology. Currently 5G term is not officially used. Fifth generation negotiate on (Voice over IP) VOIP-enabled devices that user will get a high level of call volume and data transmission. Fifth generation technology will be done all the requirements of customers who always want advanced features in cellular phones. The main features in 5G mobile network is that user connect to the multiple wireless technologies at the same time and can switch between them. This forthcoming mobile technology will support IPv6 and flat IP. Fifth generation technology will offer the services like Documentation, supporting electronic transactions (e-Payments, e-transactions) etc. Index Terms— 5G, 5G Architecture, Evolution from 1G to 5G, Comparison of all Generations.

Key Words: Wireless Communication, Cellular Networks, 5G.

I. INTRODUCTION

Wireless communication has started in early 1970s. In next four decades, a mobile wireless technology has evolved from 1G to 5G generations [1-3]. Fifth generation encompasses high speed standard and protocols where a user never experienced before. The Fifth generation technologies offer various new advanced features which makes it most powerful and in huge demand in the future. Presently the planet is driven by 4G (UMTS-Universal Mobile Telecommunication System, cdma2000), LTE (Long Term Evolution), Wi-Fi (IEEE 802.11 wireless networks), WiMAX (IEEE 802.16 wireless and mobile networks),as well as sensor networks, or personal area networks (e.g. Bluetooth, ZigBee) [4-8]. Mobile terminals include variety of interfaces like GSM which are based on circuit switching. All wireless and mobile networks implements all- IP principle, that means all data and signaling will be transferred via IP (Internet Protocol) on network layer. Fifth generation technology will have support like camera, MP3 recording, video player, large phone memory, audio player etc. that user never imagine and for children rocking fun with Bluetooth technology and Pico nets. The fifth generation wireless mobile multimedia internet networks can be completely wireless communication without limitation, which makes perfect wireless real world – World Wide Wireless Web (WWWW). Fifth generation is based on 4G technologies. The 5th wireless mobile internet networks are real wireless world which shall be supported by LAS- CDMA(Large Area Synchronized Code Division Multiple Access),OFDM (Orthogonal frequency-division multiplexing), MCCDMA (Multi-Carrier Code Division Multiple Access),UWB (Ultra-wideband), Network-LMDS (Local Multipoint Distribution Service), and IPv6 [9]. Fifth generation technologies offers tremendous data capabilities and unrestricted call volumes and infinite data broadcast together within latest mobile operating system. Fifth generation should make an important difference and add more services and benefits to the world over 4G [10]. Fifth generation should be more intelligent technology that interconnects the entire world without limits. This generation is expected to be released around 2020. World of universal, uninterrupted access to information, entertainment and communication will open new dimension to our lives and change our life style significantly.

II. EVOLUTION OF WIRELESS TECHNOLOGIES

Mobile communication has become more popular in last few years due to fast revolution in mobile technology [11].

This revolution is due to very high increase in telecoms customers. This revolution is from 1G- the first generation, 2G- the second generation, 3G- the third generation, and then the 4G- the fourth generation,5G-the fifth second generation.

A. First Generation (1G) 1G emerged in 1980s. It contains Analog System and popularly known as cell phones. It introduces mobile technologies such as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT). It uses analog radio signal which have frequency 150 MHz, voice call modulation is done using a technique called Frequency-Division Multiple Access (FDMA) [12]. It has low capacity, unreliable handoff, poor voice links, and no security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties.

B. Second Generation (2G) 2G emerged in late 1980s. It uses digital signals for voice transmission and has speed of 64 kbps. It provides facility of SMS (Short Message Service) and use the bandwidth of 30 to 200 KHz. Next to 2G, 2.5G system uses packet switched and circuit switched domain and provide data rate up to 144 kbps. E.g. GPRS, CDMA and EDGE [13-16].

C. Third Generation (3G) it uses Wide Brand Wireless Network with which clarity is increased. The data are sent through the technology called Packet Switching. Voice calls are interpreted through Circuit Switching. Along with verbal communication it includes data services, access to television/video, new services like Global Roaming. It operates at a range of 2100MHz and has a bandwidth of 15-20MHz used for High-speed internet service, video chatting.3G uses Wide Band Voice Channel that is by this the world has been contracted to a little village because a person can contact with other person located in any part of the world and can even send messages too.

D. Fourth Generation(4G) 4G offers a downloading speed of 100Mbps.4G provides same feature as 3G and additional services like Multi-Media Newspapers, to watch T.V programs with more clarity and send Data much faster than previous generations. LTE (Long Term Evolution) is considered as 4G technology. 4G is being developed to accommodate the QoS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and other services that utilize bandwidth.

III. COMPARISION OF 1G TO 5G

Various generations are compared in Table 1 in terms of data bandwidth, multiplexing, switching and core network.

Table 1: Comparison of Generations.

Contents	1G	2G	3G	4G	5G
START	1970	1990	2004	NOW	2020
DATA BW	2kbps	64kbps	2Mbps	1Gbps	>1Gpbs
MULTIPLEX	FDMA	TDMA	CDMA	CDMA	CDMA
SWITHCING	CIRCUIT	CIRUIT	PACKET	ALL PACKET	ALL PACKET
CORE NETWORK	PSTN	PSTN	PACKET N/W	INTERNET	INTERNET

IV. 5G ARCHITECTURE

Fifth generation mobile systems model is all-IP based model for wireless and mobile networks interoperability The All-IP Network (AIPN) is capable to fulfill increasing demands of the cellular communications market. It is a common platform for all radio access technologies [12]. The AIPN uses packet switching and its continuous evolution provides optimized performance and cost. In fifth generation Network Architecture consist of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies (RAT) [13]. In 5G network Architecture, all IP based mobile applications and services such as Mobile portals, Mobile commerce, Mobile health care, Mobile government, Mobile banking and others, are offered via Cloud Computing Resources (CCR). Cloud computing is a model for convenient on-demand network access to configurable computing resources (e.g., networks, servers, storage, applications, and services) [14-19]. Cloud computing allows consumers to use applications without installation and access their personal data at any computer with internet access. CCR links the ReconfigurableMulti Technology Core (RMTC) with remote reconfiguration data from RRD attached to Reconfiguration Data models (RDM). The main challenge for a RMTC is to deal with increasing different radio access technologies. The core is a convergence of the nanotechnology, cloud computing and

radio, and based on All IP Platform as shown in Figure 1. Core changes its communication functions depending on status of the network and/or user demands. RMTC is connected to different radio access technologies ranging from 2G/GERAN to 3G/UTRAN and 4G/EUTRAN in addition to 802.11x WLAN and 802.16x WMAN. Other standards are also enabled such as IS/95, EV- DO, CDMA2000...etc. Interoperability process-criteria and mechanisms enable both terminal and RMTC to select from heterogeneous access systems.

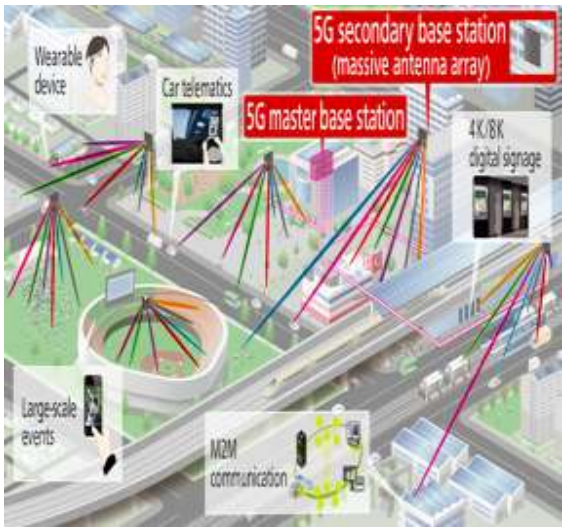

Figure 1: Basic Architecture of 5G

V. CLOUD COMPUTING

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" a definition from. Hence, cloud computing is a technology that uses the internet and central remote server to maintain data and applications. In 5G networks this central remote server could be a content provider. Cloud computing allows consumers and business to use applications without installation and access their personal files at any computer with internet access. The same concept is going to be used in multi -core technology where the user tries to access his private account form a global content provider through cloud computing.

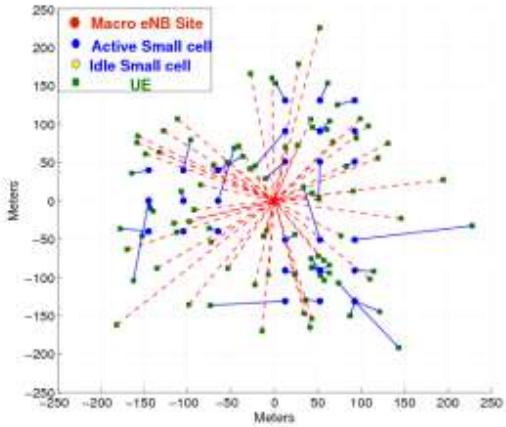

Figure 2: Active-idle Cell Range

VI. QUALITY OF SERVICE

Next Generation Networks (NGN) consists of support functionalities for data transport, and control transport, as well as functionalities for support of latency, error rate and uptime. Quality of service also involves controlling and managing network resources by setting priorities for specific types of data (video, audio, files) on the network. QoS is exclusively applied to network traffic generated for video on demand, VoIP, streaming media, videoconferencing and online gaming. The primary goal of quality of service is to provide priority to networks, including dedicated bandwidth, controlled jitter, low latency and improved loss characteristics. Its technologies supply the elemental building blocks that will be used for future business applications in campus, wide area networks and service provider networks. There are three fundamental components for basic QoS implementation:

- Identification and marking techniques for coordinating QoS from end to end between network elements.
- QoS within a single network element.
- QoS policy, management, and accounting functions to control and administer end-to-end traffic across a network. The internet of Things covers these aspect as shown in Figure 3 [20-25]

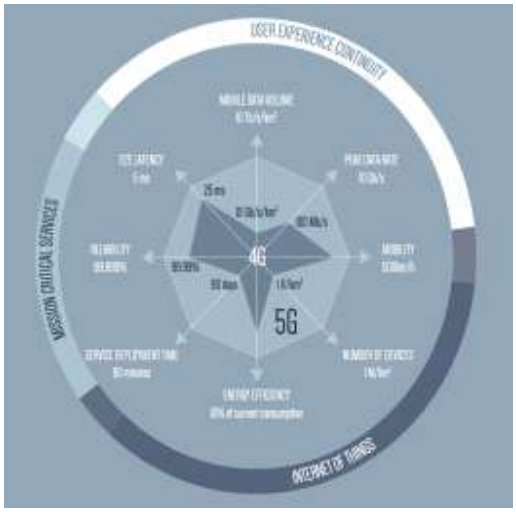

Figure 3: User Experience-Internet of Things

VII. WHY 5G?

Very High speed, high capacity, and low cost per bit. It supports interactive multimedia, voice, video, Internet, and other broadband services, more effective and more attractive, and have Bi-directional, accurate traffic statistics. 5G technology offers Global access and service portability. It offers the high quality services due to high error tolerance. It is providing large broadcasting capacity up to Gigabit which supporting almost 65,000 connections at a time [26-38]. More applications combined with artificial intelligent (AI) as human life will be surrounded by artificial sensors which could be communicating with mobile phones. 5G technology use remote management that user can get better and fast solution. The uploading and downloading speed of 5Gtechnology is very high. • 5G technology offer high resolution for crazy cell phone user and bi-directional large bandwidth shaping. • 5G technology offer transporter class gateway with unparalleled consistency.

VIII. CONCLUSION

The development of the mobile and wireless networks is going towards higher data rates and all-IP principle. Mobile terminals are obtaining each year more processing power, more memory on board, and longer battery life for the same applications. 5G include latest technologies such as cognitive radio, SDR, nanotechnology, cloud computing and based on All IP Platform. It is expected that the initial Internet philosophy of keeping the network simple as possible, and giving more functionalities to the end nodes, will become reality in the future generation of mobile networks, here referred to as 5G.

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