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Aim & Scope

AIM

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SCOPE

International Journal of Innovative Technology and Exploring Engineering (IJITEE) covers all topics of all engineering branches. Some of them are Computer Science & Engineering, Information Technology, Electronics & Communication, Electrical and Electronics, Electronics and Telecommunication, Civil Engineering, Mechanical Engineering, Textile Engineering and all interdisciplinary streams of Engineering Sciences. The main topic includes but not limited to:

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An Improved Algorithm for Constructing Large Fractional Factorial Designs

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A B S T R A C T

Fractional factorial designs (FF-Designs) are widely used in various engineering, industrial and scientific areas for their run size economy and cost-effective.A complete catalogue of FF-Designs provide a helpful way for experimenters to choose best designs, in this paper we introduce an improved algorithm for constructing the set of all non-isomorphic 2-level regular FF-Designs by developing a new sequential generation procedure that reduce significantly the number of candidate designs from which isomorphs need to be removed, to illustrate the efficiency of the proposed method some comparisons with existing generation procedure are given. The present algorithm is able to enumerate all 16384-run and all 32768-run designs with resolution 9, we extend the catalog by all 65536-run designs with resolution 10, all 131072-run designs with resolution 10 up to 22 factors, all 262144-run designs with resolution 11 and all 524288-run designs with resolution 12, which were not generated in literature.

Keywords: Automorphism, isomorphism, minimum aberration, resolution, world length pattern.

I. INTRODUCTION

Design of experiments is no doubt the most widely used technique in scientific investigations for screening the relationship between factors affecting an experiment and its outputs. This technique involves two basic aspects, designing the experiment (data collection) and analyzing the experiment (data analysis). Designing the experiment is arguably the most important part of this approach. Fractional Factorial Designs (henceforth FF-Designs) are one of the most important and useful tools for experimental designs, they have successfully used in different scientific investigations and engineering applications to determine how factors affect some response. FF-Designs reduce experimental cost by carefully choosing a fraction of a full factorial design in terms of runs. One of the main tasks in planningsuch an experiment is the selection of an appropriate FF-Design. Optimal designs are identified according to some design criterion. This requires that a catalog of candidate designs be available for searching for the optimal design. Recently large FF-Designs had a special interest; real application of large FF-Designs have been reported, for more details see [11], [15].

For constructing the entire set of distinct FF-Designs the isomorphism problem must be addressed, two(2^{n-k}) FF- designs are called isomorphic if one can be obtained from the other by reordering the runs, relabeling the factors and/or relabeling the factor levels. The number of isomorphic designs becomes very large when both the run size and the number of factors increase in a example given by [6] the

number of possible combinations in a 2^{15-10} is 5311735 designs, where the number of unique designs is 144. The isomorphic designs are mathematically and statistically equivalent under some classical ANOVA models. Therefore, constructing a catalog of FF-Designs keeping all of these equivalent designs waste the experimental and computational efforts. To discard the isomorphic designs we have Two solutions: the first is to eliminate these redundant designs after generation by using a check isomorphism procedure, which involves comparing a combinatorially large number of designs, where each comparison in itself is a costly one, for two (2^{n-k}) designs with n-factors each having 2 levels and N-run sizes a complete search compares $O(N!n!2^k!)$ designs, which is an NP hard problem even if the values of (n-k) are of moderate magnitudes, different check isomorphism procedures was proposed in literature see for example [1]. The other solution is to provide a generation procedure that constructs the entire non-isomorphic designs set without testing all possible designs for isomorphism. Because of the difficulties in identifying isomorphic designs, reducing the collection of designs from which isomorphs are to be eliminated is important.

The problem of constructing the complete set of designs is firstly attacked by [7] who proposed a stage by stage construction algorithm, [6] proposed a sequential construction algorithm that generates the resulting designs only from the set of non-isomorphic designs. [2] Introduced a modified procedure that combined [6] procedure with the search-table approach of [9]. [15] Procedure allows a design to be constructed only from its minimum aberration (henceforth MA) delete-one-factor (D-O-F) projection. [14] Extended some results from graph isomorphism literature to improve the design generation algorithm of [11]. Many other generation procedures were proposed in literature to produce FF-designs according to a particular criterion such as minimum aberration (MA) see for example: [10], [8] and [13].

In this paper, a modified sequential construction method was proposed for generating the catalog of non-isomorphic FF-Designs, our algorithm combine the delete one factor projection (D-O-F) method used by [15] for generating designs only from their MA projection in the built-up process, with the candidate word reduction extended by [14] to obtain a powerful generation method that reduce significantly the number of isomorphism checks, a comparison with existing methods demonstrate this efficiency.

Section 2 gives some preliminaries. Section 3 presents the construction method used to provide the catalog of all distinct FF-Designs with the enumeration algorithm. Section 4 describes the results of the proposed generation procedure and gives a comparison of our algorithm with existing methods in the literature. Section 5 gives some concluding remarks and possible extensions.

II. PRELIMINARY RESULTS

A regular two-level FF-design 2^{n-k} is a 2^{-k} fraction of the full factorial design, with k factors, each at two levels, and $N = 2^{n-k}$ runs, the 2^{n-k} design is completely determined by k independent defining words (or generators). The set of words formed by all possible products of the k generators gives the defining relation of the design. Including , the complete set of defining words called defining contrast subgroup consists of 2k words. Let C be the set obtained from the n-k basic factors, the elements of C are the candidate defining words. A word consists of letters, where each letter denotes a factor; the length of a word is the number of letters in the word. The vector $(A_1(D), A_2(D), ..., A_n(D))$ is called the word length pattern (WLP), where $A_i(D)$ is the number of words of length i in the defining relation of a design D.

Introduced by [4], the resolution of a design D is the integer R such that $A_i(D) = 0$ for $i = 1, ..., R-1$ and $A_R(D) > 0$. We say that a design D is of maximum resolution R_{max} if there is no other 2^{n-k} design with resolution higher than R_{max} .

To select best designs from those with same resolution, [10] proposed the concept of aberration as a natural extension of the resolution, for two FF-Designs D_1 and D_2 let T be the smallest integer such that $AT(D_1)<AT(D_2)$ then D_1 is said to haveless aberrationthan D_2. A 2^{-k} design is called an MA design if no other 2^{-k}design has less aberration.

A. Candidate defining word reduction method

A relabeling of factor labels of a design D, such that the design obtained after relabeling is identical to D is an automorphism of the design D , this concept is proposed by [14], who extended the automorphism of a graph proposed by [5] to reduce the candidate defining words in C, the main idea of this method is that if a candidate defining word C_1 is isomorphic to an other candidate defining word C_2under an automorphism of the design D (called parent design), then the obtained designs (or child designs) after adding C_1 and C_2 to D are isomorphicto each other (see Theorem 1 in [14]). So eliminating theisomorphic elements of C under the factors relabeling of the parent design reduce the number of words in .

B. Delete one factor

The D-O-F projection method was proposed by Blockand Mee. Let denote by D(-i) the resulting $2^{(n-k)-k-1)}$ design when the i^{th} factor of a 2^{n-k} design is deleted, where i = 1, ..., n. To illustrate this method we considered an example given by [3]:

Consider a design $D(2^{9-3})$ with the defining relation: I = 1237 = 1458 = 234578 = 12469 = 34679 = 25689 = 1356789. The design has the following nine D-O-F projections:

- For $D(-1)$we obtain 2^{8-2}designs with WLP=(0,2,1)
- For $D(-2)$ or$D(-4)$ we obtain 2^{8-2} designswith WLP=(1,1,0,1)
- For $D(-3)$, $D(-5)$, $D(-7)$ or $D(-8)$ we obtain$D(2^{8-2})$designswith WLP=(1,2)
- The even designs with WLP = (2, 0, 1) if one deletes factors 9.

[15] Extended this method to generate designs only from their MA delete-one-factor projection. Note that MA designs are not necessary unique. For the given example the MA delete-one-factor projection are $D(2^{8-2})$ designs with WLP= (0, 2, 1).

III. CONSTRUCTION METHOD

A. Basic Idea

Generally the FF-Designs are constructed in a sequential manner as in [6]. The constructing algorithm contains two main components the design generation procedure and the isomorphism check.

Let be the set of candidate words from which the factors can be added, these candidate words are defining words constructed from the first factors, [6] proposed to construct this catalog of $2^{(n+1)-(k-1)}$ designs only from the set of non-isomorphic (a = n - k) designs with resolution > R denoted by $D^{R}_{n,k}$ the designs are constructed by adding a candidatedefining word to each design in $D^{R}_{n,k}$. Let denoted by $D^{+}_{n+k,k+1}$ the resulting class of designs after adding a factor, from , at a time in each design in $D^{R}_{n,k}$. The resulting $D^{+}_{n+k,k+1}$ contain not only the non-isomorphic designs but also isomorphic designs and some designs with resolution more than R, using necessary conditions such as word length patterns andletter patterns this set is partitioned into different categories so the test for isomorphism must be applied inside each subset .

B. A modified procedure

To reduce the number of isomorphism checks we must reduce the number of equivalent designs in the intermediate set $D^{+}_{n+k,k+1}$ for this we propose a combined approach that differs from Chen et al generation on two points:

- We use the delete-one-factor projection described in section 2; to allow a design to be generated only from one of the "parent" designs.
- We reduce the set C by using the candidate word reduction.

[15] procedure reduces significantly the number of generating designs because with the [6]construction a $2^{(n+1)-(k-1)}$ design can be generated from as many asn+1 distinct designs, but the problem with the Xu's procedure is that a 'child' designs is not generated uniquely from the same parent design (in this case

generated from the MA delete one factor projection deigns), so reducing the number of isomorphic designs generating from the same 'parent' design will reduce the total number of isomorphic designs produced by

Table- I: Number of Non isomorphic Designs

n \ run size	4096(7)	4096(8)	8192(8)	16384(8)	16384(9)	32768(9)	65536(10)	131072(10)	262144(11)
13	7	6							
14	17	7	7						
15	27	4	14	8	7				
16	48	5	16	24	9	8			
17	95	5	23	50	2	17	8		
18	113	2	39	131	0	14	14	9	
19	84	1	30	450	0	7	7	24	9
20	35	1	27	*	0	3	3	29	17
21	22	1	13	*	0	0	2	30	7
22	17	1	10	*	0	0	0	39	2
23	13	1	9	*	0	0	0	*	1
24	0	1	10	*	0	0	0	*	0

the algorithm without using the isomorphic check procedure, for this we combined this generation procedure of [15] with a result given by [14] who proposed a useful reduction of the set C by extending the automorphism of a graph to the automorphism of the FF- Designs.

Our proposed method gives a more efficient generation procedure because the smallest the set C is the smallest is the number of the designs to be entertained in the intermediate set; for the isomorphic check procedure we use the isomorphism check procedure proposed by [14]. The description of the steps is given in the enumeration algorithm.

C. Enumeration algorithm

The algorithm is implemented in a package nauty based on [12], for more details on the isomorphism check procedure see [14].

Input: A collection of all non-isomorphic 2^{n-k} regular FF-Designs with resolution R> r.

1. Construct the set C of all possible 2^{a-1} words, except I, from the (a = n - k) basic factors.
2. For each design $d \in D^{R}_{n,k}$.
   a. Construct the set of unique defining words C, using the automorphisms of d on C.
   b. Let dx be the candidate design after adding to d a defining word from C, if d is MA over all delete-one-factor projections, add dx to the $2^{(n+1)-(k+1)}$ set of designs.
3. Form the set $D^{+}_{n+1,k+1}$ of candidate designs by combining all the designs constructed from each d.
4. Form the subsets $G_1, G_2, \dots, G_m$ by partitioning the set $D^{+}_{n+1,k+1}$, such that designs in each subset have the same WLP.
5. Compare designs within each subset $G_i; i = 1, \dots, m$, to remove isomorph, using the graph based isomorphism check.
6. Construct the set $D^{R}_{n+1,k+1}$ of non-isomorphic $2^{(n+1)-(k+1)}$ designs by collecting all the remaining designs (in these subsets).

Output: A collection of all non-isomorphic $2^{(n+1)-(k+1)}$ regular FF-Designs with resolution $R \geq r$.

IV. RESULTS

Using the proposed method described in this paper we are able to enumerate all 4096-run designs of resolution 7 and 8, we extend the catalog by all 8192 and all 16384 (up to 19 factors) designs with resolution 8, all 16384, 32768 and 65536 (upto21factors)rundesignswithresolution9,all 131072(up to 22 factors), all 262144 and 524288 run designs with resolution respective 10, 11 and 12, the complete set table of designs can be obtained from authors. Table 1 give's the number of non isomorphic designs produced by our algorithm, the numbers of non isomorphic designs match with results in the literature.

To illustrate the difference between the generation procedures, we compare the number of designs generated in creating a catalog of 128-run size, see (Table 2), both Xu and Schrivastava and Ding method's reduce the number of designs considered, for large factors the generation procedure of Xu introduce fewer designs in the intermediate set, as the table 2 show's for n > 9 our modified procedure gives best results in comparison with the other procedures; taking for example n = 11, the number of designs generated with Chen et al is of 711, for Xu 502 and for Schrivastava and Ding 703. For us the number of designs generated is from 219, the number is divided by 3.3, note that a comparison with results given by Xu method is also a comparison with [13] procedure because Ryan and Butlutuglo used the same generation method as in [15] .

Table- II: Number of designs enteratained in Creating Catalog of 128-run Designs of Resolution 4

Procedure n	8	9	10	11	12	13	14	15	16
Chen et al	99	63	180	711	2039	4963	11128	22607	41541
XU	99	299	341	502	890	1952	4028	7969	14176
Shrivastava and Ding	98	62	177	703	2026	4952	11110	22572	41421
Authors	99	145	97	219	597	1450	3139	6591	12739
True	5	13	33	92	249	623	1525	3522	7500

Table 3 show's a comparison between the number of designs entertained by our method and schrivastava and Ding method in creating a catalog of 4096-run with resolution 7, for n > 14 the number of designs considered for our method are reduced by 45%-81%. The last row of tables 2-3 presents the number of unique designs.

Our procedure improve the existing methods by introducing a construction method that reduces significantly the number of tests for isomorphism, this reduction procedure is important because of the difficulties in identifying isomorphic designs.

TABLE- III: NUMBER OF DESIGNS ENTERATAINED IN CREATING

Catalog of 4096-run Designs of Resolution 7

Procedure n	13	14	15	16	17	18	19	20	21
Shrivastava and Ding	2510	493	1694	1711	4043	4489	1513	622	272
Authors	2510	2430	476	313	1532	1098	514	196	150
TRUE	7	17	27	48	95	113	84	35	22

V. CONCLUSIONS

The construction of fractional factorial designs is a challenging problem especially with large run sizes and factors, In this paper we proposed an efficient algorithm that constructs the catalog of all non isomorphic FF-Designs by adopting a combined approach, the main contribution of this paper is in the generation phase of the algorithm, we reduce significantly the number of designs to be tested for isomorphism, a comparison with existing methods show this.The proposed algorithm allow us to enumerate the set of all nonisomorphic designs to reach the size of 524288-run designs; this extends largely what is proposed in the literature. With some modifications our design generation procedure can be extended to other classes of designs such as split-plot designs.

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Healthy Fruits Image Label Categorization through Color Shape and Texture Features Based on Machine Learning Algorithm

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A B S T R A C T

The fruit categorization according to their visual quality has recently experienced tremendous growth in the field of agriculture and food products. Due to post-harvest loses during handling and processing, there is an increasing demand for quality products in agro industry which requires accuracy to predict the fruit. Various techniques of machine learning have been successfully applied for classifying the fruit built on binary class. In this paper, machine leaning technique is used to automate the process of categorization and to improve the accuracy of different types of fruits by feature selection. To categorized images domain specific features such as color, shape and textual features are considered. Statistical color features are extracted from the image, bounding box feature for shape features and gray-level co-occurrence matrix (GLCM) is used to extract the textual feature of an image. These features are combined in a single feature fusion. A support vector machine (SVM) classification model is trained using training set features on fruit360 dataset which includes six fruit categories (classes) with two sub category (sub-classes) which builds multiclass classification task. We present one-vs-one coding design of Error correcting output codes (ECOC) and apply to SVM classifier; validation followed a fivefold cross validation strategy. The result shows that the textual features combined with color and shape feature improved fruit classification accuracy.

Keywords : Categorization, SVM-ECOC, Machine learning

I. INTRODUCTION

India is considered as the second largest producer of fruits and vegetables. One of the challenging problem affecting the country's agriculture market is post-harvest loses. Annually the country suffer huge losses due to post-harvest loses. The various post-harvest losses from the producer to consume includes lack of proper harvest practices, transportation and cold storage which results in 35% to 40% of fruit and vegetable produced being wasted The research work at the department of nano science and technology at TNAU has been trying to reduce post-harvest losses of fruits by slowing down the ripening and control loses at farm level using Enhanced Freshness Formulation (EFF) by dipping fruit(mangoes and bananas) in EFF solution. It also adopt various methods for controlling losses in package houses, transportation and retail shops by placing a EFF based tablet in a fruit carton which results in increased shelf life[1].

The initial and most important process in post harvesting sequence is sorting and grading of harvested produce. In India manual sorting and grading is performed by human based on visual quality inspection.

But it is costly, tedious and time consuming [2]. Huge losses occur in post-harvest during handling and processing, with the increasing demand for quality products in agro industry requires accuracy .The quality of the fruit is classified into internal and external factors [3]. The external quality factor includes size, image-color, image- shape and image-texture. In order to prevent losses of post harvesting there is a need to automate the process of categorizing the fruit using external factors. Automatic categorization of fruits from images is one of the most difficult tasks in an emerging domain of research that combines the aspect of computer vision and machine learning. One of the challenging researches in computer vision is to automatically categorize image using low level features [4].

Image categorization has been referred to as a process in which labeling of images is done into one of a number of predefined categories. Generally it depends on combination of approaches such as statistical (mean, variance and entropy), structural (part of the object) and spectral approach [5].

The human vision can easily categorized fruit images among various categories even though they are changes in numerous factors such as illumination, noise, viewing angle etc. The categorization of common fruits according to their visual features such as image-color, image-shape and image-texture are fundamental aspect for visual content. Human perception of certain visual features could be associated with different classes of fruit objects Images. Classification of image deals with multi class categorization based on image feature similarity by using the visual descriptor in large scale database. Multiclass categorization image classification problem is motivated by the need to classify fruit object based on their category.

The purpose research performs automation of fruit image categorization using external features through machine learning techniques. The paper presents two objectives. In the first case feature extraction is performed using color and shape feature. In the second case three features color, shape and texture are considered and finally the accuracy of each case is presented. A machine learning model is proposed where the feature extraction involves color, shape and texture algorithms of each image. The classification uses SVM (support vector machine) with ECOC framework. Evaluation of model is carried out using performance metric. The rest of the paper organized is as follows. In Section 2, methodology is presented. Section3, describe the SVM with ECOC framework. In Section 4, we discuss the classification steps, section 5, experimental results and Analysis, section 6; present the discussion and finally conclusion and probable future work.

Table 1: Summarization of Binary and Multiclass SVM algorithms

Purpose & ref	Features	Images	Dataset	Classifier/Algorithm	accuracy	Finding
To classify dates fruit automatically [6]	Shape & color	120	(Web scraping)	Binary SVM	100%	It classifies the fruit type eatable or non- eatable using binary SVM. It is proven high degree of accuracy.
To classify different fruits automatically[11]	Color, texture & shape	1653 (18 categories)	On-site data collection &(web scraping)	Multiclass Kernel SVM (KSVM)	88.2%	It classifies the fruits with KSVM. It proved that multiclass kernel SVM perform accuracy with 88.2%.
Fruit recognition system with KNN [12]	Shape, size & texture	36	-	KNN	95%	It classify & identify several fruits with nearest neighbor (KNN) algorithm improve accuracy.
Fruit recognition with ANN[15]	Texture, color& shape.	150 (6 categories)	-	ANN	90%	It classifies several fruit with artificial neural network.
Fruit classification using statistical feature [14]	Color and texture	941 (10 categories)	Supermarket produce	Multiclass SVM	95.3%	Proposed fruit classifying using statistical and co-occurrence featured from the wavelet transform. It proves that Multiclass SVM perform accuracy with more than 95%
Fruit classification using surface and geometric information [15]	Color, texture ,size & shape	2633 (15 categories)	Supermarket produce	k-nearest neighbor	81.94%	
Fruit Recognition [16]	Color & texture	240 (30 images per class) (8 categories)	(web scraping)	Multiclass SVM	-	Proposed method uses Grabcut segmentation for background removal, glcm texture and statistical color feature. Multiclass SVM classify the fruit

of model is carried out using performance metric. The rest of the paper organized is as follows. In Section 2, methodology is presented. Section3, describe the SVM with ECOC framework. In Section 4, we discuss the classification steps, section 5, experimental results and Analysis, section 6; present the discussion and finally conclusion and probable future work.

In literature much research work is discussed in automation of fruit classification using binary class and multiclass SVM. In binary class to classify the dates whether it is eatable and non- eatable with an 100%accuracy [6], for multiclass such as date fruit classification with one against all method [7] ,fruit and branches identification with one against one method[8],Cape gooseberry fruit classification for visual ripeness[9], categorization of fruit using different classifiers[10]. Zhang & Wu, proposed a multiclass KSVM method for classification of fruits [11]. Fruit recognition with (K-nearest neighbors) KNN [12]. Naskar and Bhattacharya [13] proposed fruit recognition with ANN.

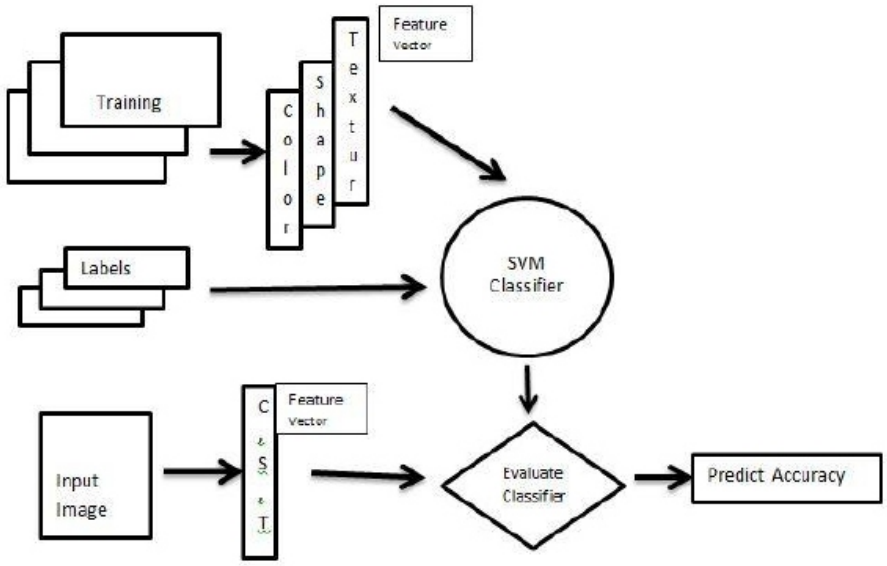


Fig1: Block Diagram of fruit Categorization Scheme

Image-Database

The Image-Database of 5817 images includes 6 different categories: Apples, Avocado, Bananas, Cherrys, Grapes and Lemons from Fruits360 dataset [17]. The Table 2: presents total fruit categories with sub category with in the same classes. The Fruit360 dataset consists of 81 distinct fruit object category folders, from which 12 category folders has been taken and designed as six fruit category along with its sub category.

Table 2: Total No of Image for Categories with Sub Category

Category	Apples	Avocados	Bananas	Cherrys	Grapes	Lemons
Sub category/ No of Image	Apple Red Delicious-490 Apple Golden 3-481	Avocado-unripe-427 Avocado- ripe-491	Banana -Green-490 Banana- Red-490	Cherry-Red-492 Cherry-Yellow-492	Grape Pink-492 Grape White 2-490	Lemon-492 Limes-490
Total	490+481=971	427+491=918	490+490=890	492+492=984	492+490=892	492+490=892

Feature Extraction and Preprocessing

Feature Extraction has been referred to as a process in which the raw image is represented in a reduce form in order to make decision making easier when performing image classification or recognition [18]. Feature extraction has been classified into two types: Low Level extraction refers to directly feature extraction from the image without any description of object. High level refers to feature extraction involving shapes and objects finding in image based on low level [19]. The Low Level feature can be further categorized into the following:

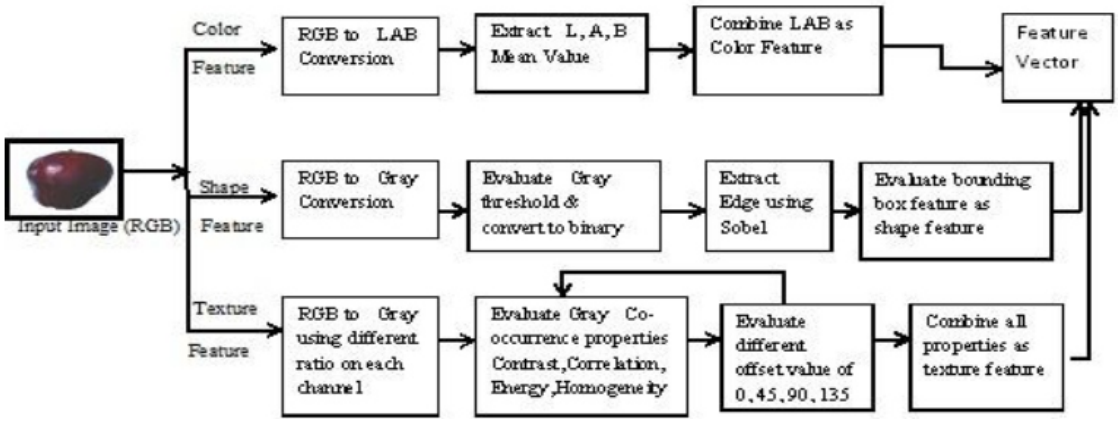


Fig2: Image Fruit-Feature Extraction Process

General feature (color, texture and subarea of image) and Global Feature (feature calculation on entire image or subarea of the image) and Domain specific feature (human image faces, image-fingerprints etc.)[20].

Color-Feature Extraction

The image-color is extensively measured visual descriptor [21]. The analysis of the image descriptor based on low- level- features from the image. Generally the color image descriptor is defined into color spaces of three dimensional such as RGB, LAB (luminance or intensity, chromaticity layer 'a', chromaticity layer 'b'), HSV (Hue, Saturation and Value). The propose work uses color features that has been are extracted with LAB Color components, where L refers to luminosity, 'A' signifies the color which falls along red-green axis and 'B' signifying the color falling along the blue-yellow axis.

Step1: Convert RGB-image to LAB results in the luminance or intensity of that image.
Step2: Evaluate the statistical measure, Mean value of L, A and B.
Step3: Combine LAB as Color Feature.

Shape-Feature Extraction

The image-shape is primitive visual descriptor for image description. To determine the shape of a given image object in image recognition and classification process, it has been stated by [22] that it must matches a model sufficiently.

Step 1: Convert an RGB image into Gray scale
Step2: Evaluate the Gray threshold and convert into Binary Image
Step3: Evaluate the Edges using sobel
Step 4: Evaluate bounding box as shape feature

Texture- Feature Extraction

Texture Feature is considered as one of the important feature that has been refers to as the inherent surface property of an image object and its relation to its surrounding. To extract texture feature co-occurrence matrix is used. The input image is converted into grey scale image using formulae [21] in equation (1).

$$Yc=0.29*Rc+0.589*Gc+0.114*Bc \quad (1)$$

Yc refers to gray scale value, Rc- Red Component, Gc- Green Component, Bc -Blue Component.

The statistical measure used for texture features are as follows: Contrast, Energy, Homogeneity, Correlation.

Table 3: Statistical Texture Feature

$Contrast = \sum_{i,j} \lvert i-j \rvert^2 \, p(i,j)$	$Energy = \sum_{i,j} p(i-j)^2$
$Homogeneity = \sum_{i,j} \frac{p(i,j)}{1+\lvert i-j \rvert}$	$Correlation = \sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j}$

The element (i, j) specifies the number of times the pixel value i occurred horizontally adjacent to a pixel with value j. The statistical properties are calculated using formulae in Table 3.

The texture-feature extraction is as follows

Step1: Color- image to grey scale conversion performed using formulae (1).

Step2: Evaluate GLCM (the gray-level co-occurrence matrix) of gray scale image.

Step3: Evaluate GLCMs. Using four Different offsets (0, 45, 90,135)

Step4: Evaluate the four statistical properties Contrast, Energy, Correlation and Homogeneity from multiple glcms.

Step5: Evaluate the statistical measure, Mean for the above four properties.

Step 6: Combine all as Texture Feature.

Training Image for category classification using Training Set Features (Color, shape, texture) and SVM

Step1: The input dataset consisting of 5817 fruit- images with 6 categories along with two subcategory of each fruit with an image size of 100X100X3.

Step2: Extract three image features (color, shape and texture).

Step3: The fruit-images divide into 70% training-data and 30% test-data. The training-data is dealt with 5Fold Cross- Validation.

Step4: Train multi class SVM with training set features.

Step5: The test-data is built by random sample of each group and it is used for classifier performance analyzing and generating confusion matrix

Step6: The accuracy is presented.

III. SVM-ECOC CLASSIFICATION

SVM has been used in different application built on categorization like classifying points into disjoined planes [23], text categorization and pattern recognition [24]. In Today's world with huge data there is a need for multiclass classification [25].It is mainly for target categories greater than two. Dietterich et al (1995) proposed ECOC framework [26] for transforming multiclass into several binary problems. The SVM when combined with ECOC enriches the system failure when solving multiclass classification [27].

ECOC reduce multiclass problem to group of binary classifiers. It consists of two schemes. "Coding Scheme: The coding design presents ways through which a multiclass problem reduced to a group of binary class problems. It describes the classes that the binary Learners are trained on". "Decoding Scheme: It presents ways to combine result obtained from binary learners. Detail explanation available [28], [29]

SVM-ECOC Algorithm:

The steps are as follows

Step 1: load Dataset of fruit image.

Step2: Feature Extraction w.r.t color, shape and texture

Step3: Define the predictor data names and response data names

Step4: Create a SVM template and specify the predictor order

Step5: Train the ECOC classifier using SVM binary learner with coding design and specify the class order

Step6: Cross-Validate Classification ECOC classifier using KFold

Step7: Predict classification accuracy for Test Data

Function to Train and Predict

To train we create a model using templateSVM [30] function that return a SVM template which is appropriate for training ECOC multiclass. The template object contains options for SVM Classification. It then trains the ECOC classifier using SVM binary learners with a one-vs.-one coding design. The function fitcecoc[29] is used for specifying SVM binary learners for ECOC multiclass learning, Cross validation is performed using 5 fold cross validation .

IV. FRUIT-IMAGE CLASSIFICATION-STEPS

Step 1: The input is a fruit-image.

Step2: Loading Database: After loading, it divide into 70% training-data and 30% testing- data.

Step 3: Fruit-Image preprocessing and feature

Extraction: The processing of training–data-set and test-data- set is performed by SVM model.

Preprocessing depending on the feature based requirement.

Step 4: The training feature extraction is done by training feature set (color, shape and texture) with function templateSVM

Step 5: Classifier trained with training feature set.

Step 6: The classifier evaluation achieved by accuracy metrics.

Step 7: Prediction Accuracy

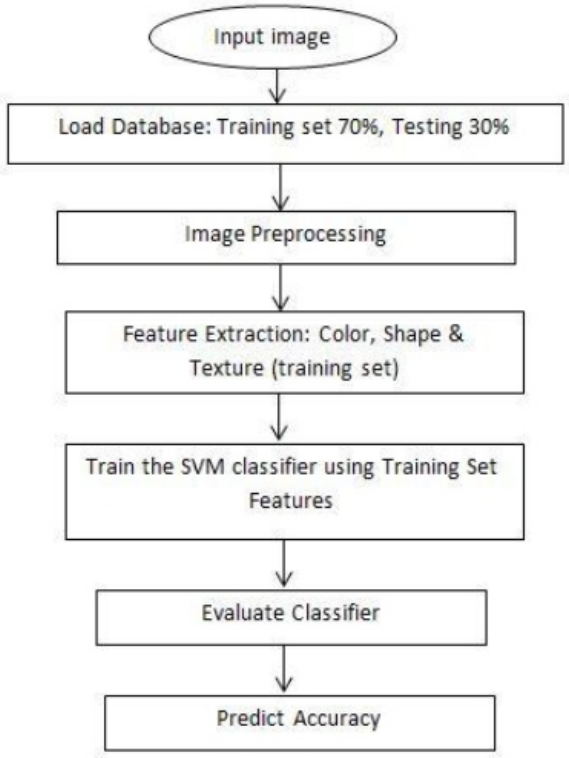


Fig 3: Fruit- Category- Classification steps

Performance Evaluation

The mostly used classification metric is Accuracy [25]. There are numerous performance metrics in literature for classification of image. The metrics of classification depends on the technique used and domain area.

Accuracy: The most widely used measure which signifies the total classification result not only individual category prediction [19].

$$\text{Accuracy} = TP+TN/TP+FP+FN+TN \quad (2)$$

The cell at the bottom (right side of the confusion matrix) represents the accuracy. The equation (2) presents the formulae. (TP, TN, FP, FN refers to true positive, true negative, false positive, false negative respectively)

V. EXPERIMENTAL RESULTS AND ANALYSIS

Multiclass image classification contains 5817 fruit-images dataset. The experiment contains 6 fruit image categories with two sub category taken from fruit 360 data set [17], it contains 70% training-data and 30% testing-data. The training-data is trained with SVM Classifier for identifying fruit category accuracy. The experiment is performed to extract the color feature by the mean (Statistical Feature) parameter value in the LAB color space presented in Table 4, Shape feature by the bounding box presented in Table 5and the Textual Feature by using GLCMs presented in Table 4.

The input is a fruit-image input, RGB image is preprocess depending on the feature extraction procedure. For color feature extraction the RGB-fruit- image is converted into LAB color space. The color image features are extracted using the mean. For Shape feature extraction the input image is converted into gray scale conversion and then the gray scale threshold is evaluated and converted into binary image. The next steps involve extracting the edges using sobel, finally evaluation of the boundary box is treated as a shape feature. The extraction of textual feature is attained by converting the image into gray scale using different ratios on each channel, then four textual characteristics (contrast, correlation, energy and homogeneity) are calculated in four angles (off sets) with GLCM

Table 4: Experimental results color & texture feature

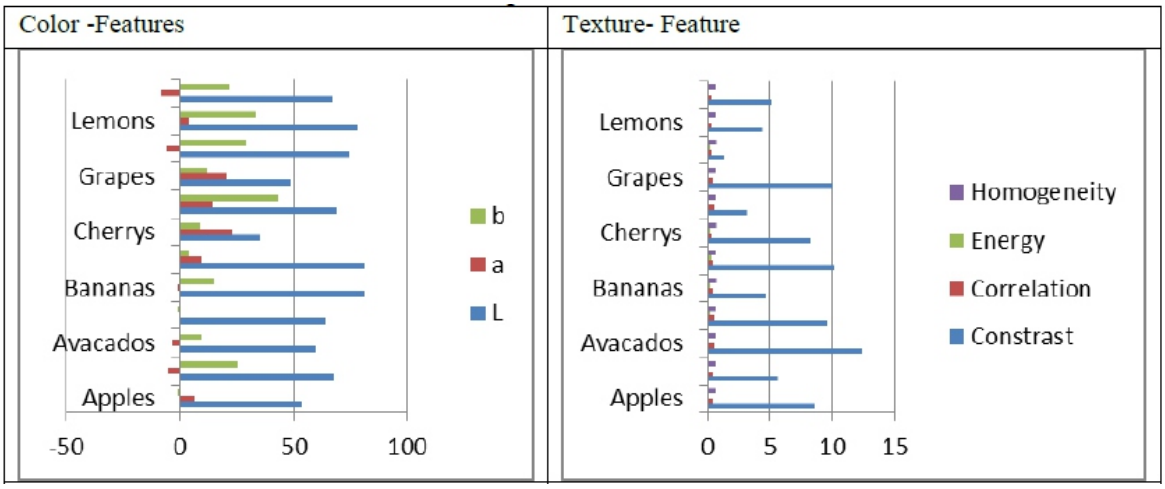


Table 5: Experimental result of shape feature

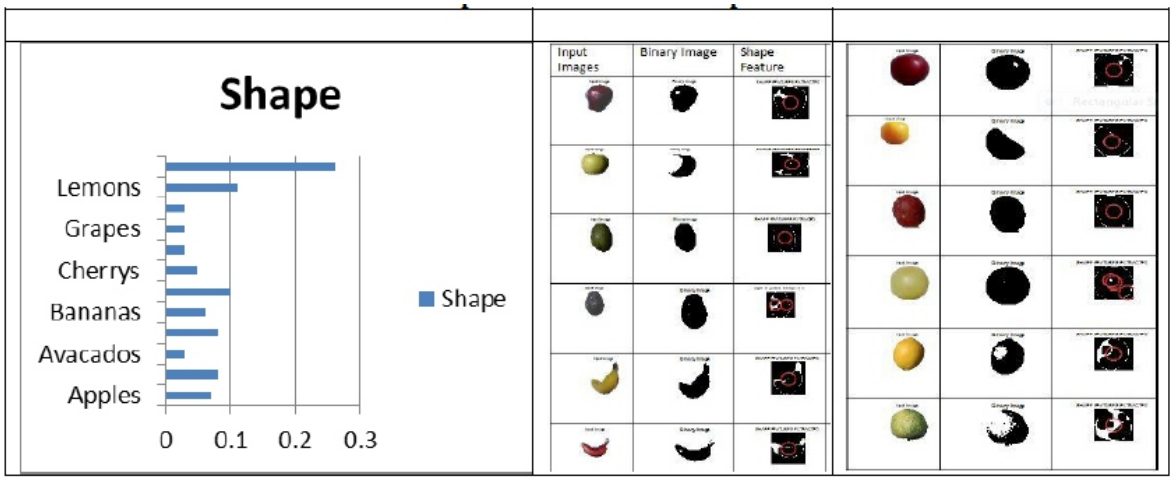
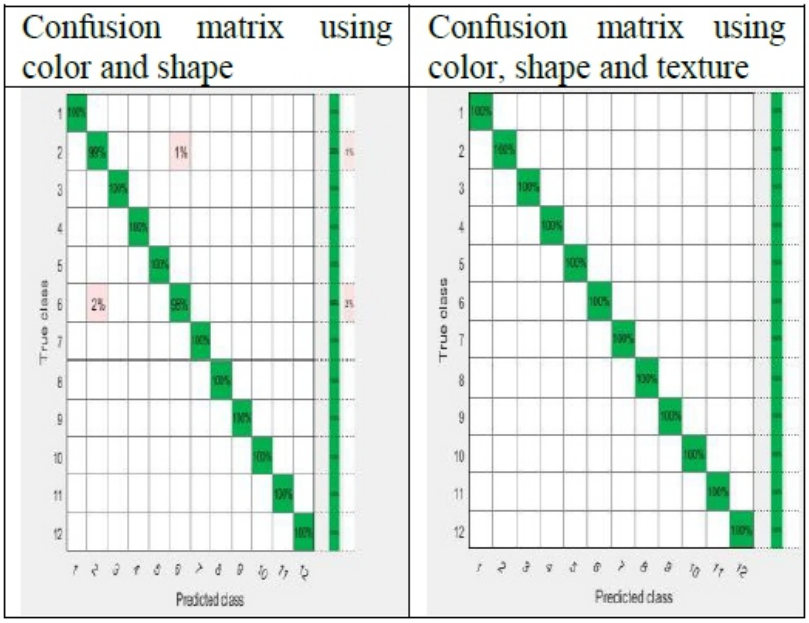


Table 6: Confusion Matrix for fruit categorization



The model accuracy is evaluated and presented in Table 6 for each category. The table consists of twelve sub categories (six fruit with two sub category) from fruit360 dataset [17].The result showed accuracy range of 98to 100% in case of two features (color and shape) and accuracy of 100% in case of three features (color, shape and texture).

Table7: Comparative result in literature

Sno	Ref	Model	Features	Dataset No of image in Dataset	Accuracy (%)
1	Kumari and Gomathy [2018] [14]	SVM	Color & Texture	941 (10 classes)	95.3
2	Alzubi et al(2018)[6]	Binary SVM	Shape and color	120	100
3	Proposed System	Multiclass SVM with ECOC	Color and shape	5817 (6 classes with in 2 sub category)	98 to 100
4	Proposed System	Multiclass SVM with ECOC	Color, Shape & texture	5817 (6 classes with in 2 sub category)	100

VI. DISCUSSION

As shown in the Table 7, the classification of fruit database into categories is determined by both feature selection and classification technique used. The proposed work uses SVM with ECOC framework for categorization of fruit with one vs. one coding design to train the classifier. The result obtained shows accuracy ranges from 98 to 100% for different category of fruits where two feature color and shape are being considered for training the model and it shows an accuracy of 100% in all the categories when training set feature (color ,shape ,texture) are used . The result presented by Alzubi et al [6] uses binary SVM for classifying the date fruit into two categories whether it is eatable or non-eatable. Another study conducted by [14] with two feature color and texture resulted in lower accuracy than that of proposed work with feature fusion (color, shape and texture feature), using multiclass approach. The training set features improves the accuracy of the model therefore high accuracy is achieved when appropriate feature selection for multiclass classification problem.

VII. CONCLUSION

Automation of fruit image categorization has been a challenging research for reducing the post harvesting loses. In this study a machine learning technique based multiclass model is built for image classification. Input to the model is a fruit-image; feature selection includes color, shape and texture. The model is trained using training set features, multiclass SVM is used as a classifier and validation is performed using 5 fold cross validation strategy. The model was tested with two cases In first case model trained on two features and the second case with three features. It was observed that when using training set features the experiment showed the classification result with 100% prediction accuracy. The multiclass SVM resulted in better accuracy with three features color shape and texture when compared to two. The result shows that the texture feature improved the overall model accuracy. The research can be helpful for the farmers to reduce post-harvest loses that occur during sorting and grading produce, in various environment, such as transport center or hypermarket, trade market can make use of this system to make profit. Additionally this method can be useful to different category objects. Furthermore mobile application can be developed for senior citizen or visually impaired daily routine schedule where human inspection exists for categorization. The future work to this research is to study accuracy prediction with additional number of categories.

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Text Based Restaurant Recommendation System using End-To-End Memory Network

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A B S T R A C T

With growing use of online content streaming websites, online shopping, and other exclusively online services, it becomes more and more imperative for technology companies to invest a lot of funds into a system to gauge user needs and requirements. To bridge this gap, there has been an influx of recommendation systems in the markets. From advertisements, to movies, and products we buy, recommendation engines are feeding on new data everyday to learn user trends. This paper tries to focus on improving the text based recommendation systems that can be implemented to leverage the vast review data that can be found on websites. We suggest using a novel memory based end-to-end network mechanism to reduce the need for long term dependencies and to reduce the need for memory intensive systems. As we generate more and more reviews and textual data on the web everyday, we need to be able to use this data to make meaningful analytical and business predictions. With the ability to perform multiple lookups, implement attention mechanism and back-propogation, this system was found to perform much better when compared to CNN, RNN and LSTM alternatives in our testing.

Keywords: end-to-end memory network, CNN, RNN, attention, LDA, LSTM

I. INTRODUCTION

Recommendation systems are programs and algorithms that help users in making a choice based on a set of predefined criteria. With the advent of content streaming websites and online retail, recommendation systems play a pivotal role in pushing new content to users. It is, therefore, very critical for companies to invest in building state of the art recommending engines to make sure all users are directed to products of their liking. There are predominantly two paradigms of recommendation systems, namely:

1) Collaborative filtering techniques
2) Content based filtering techniques

Collaborative methods are recommendations based on the past interactions recorded between users and items, and between different users. These interactions are stored in a "user-item interactions matrix". Content based approaches use additional information about users and/or items. These generally include personal information about the user to tailor-make suggestions.

Natural Language Processing is a study of linguistics using machine intelligence, generally used to parse and analyze textual and speech data. Generally, for NLP tasks, Recursive Neural Network (RNN) are

preferred for temporal structures and to parse complex lexical grammar due to their ability to preserve sequential order and model long-distance contextual information, and Convolution Neural Nets (CNN) are chosen for dealing with spatial structure due to their ability to mine semantic clues in contextual windows. While these are very useful models, they have certain limitations, namely:

1) out-of-order access
2) long-term dependency
3) unordered sets

Overcoming these limitations is a model called end to end memory networks (MemN2N), which has the following salient features:

1) Reads from memory with soft attention
2) Performs multiple lookups (hops) on memory
3) End-to-end training with backpropagation
4) Only requires explicit supervision of attention during output validation.

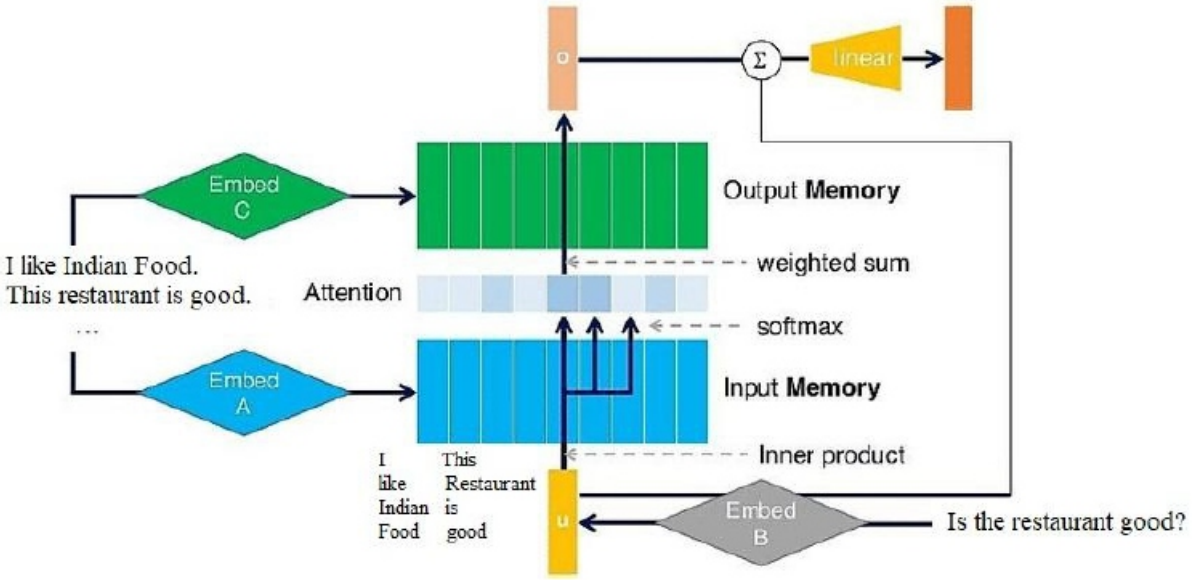
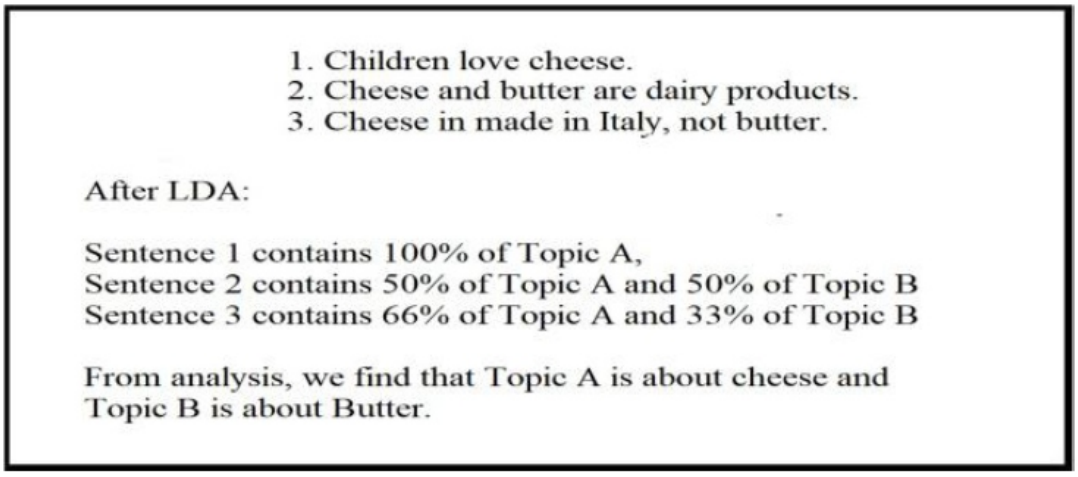


Figure 1: MemN2N workflow diagram

Figure (1) is a representation of and end-to-end memory network.

Topic modeling is a statistical method to determine the different abstract "models" that occur in a text, this helps in identifying hidden semantic structures in a text. A popular topic modeling technique is called Latent Dirichlet Allocation (LDA). LDA is a generative probabilistic model, specifically, a hierarchical Bayesian model. Using LDA, every element or an object in a sentence is treated as a mixture of the extracted topics. This technique can also be used in Document structuring and collaborative filtering. An example of LDA topic modeling is illustrated below in Figure(2):

Figure 2: Example of LDA



Attention is a mechanism that was originally invented to improve the performance of the Encoder-Decoder type RNN on machine translation. An attention mechanism takes into account the input from several time steps to make a single prediction and can be defined as components of memory networks, which focus their attention on external memory storage rather than a sequence of hidden states in an RNN. There are 2 types of attentions in Neural Networks, namely:

1) Hard Attention, which is non-deterministic and uses probability density function.

2) Soft Attention, which is Deterministic and differential.

A diagrammatic representation of attention mechanism is given below in figure(3):

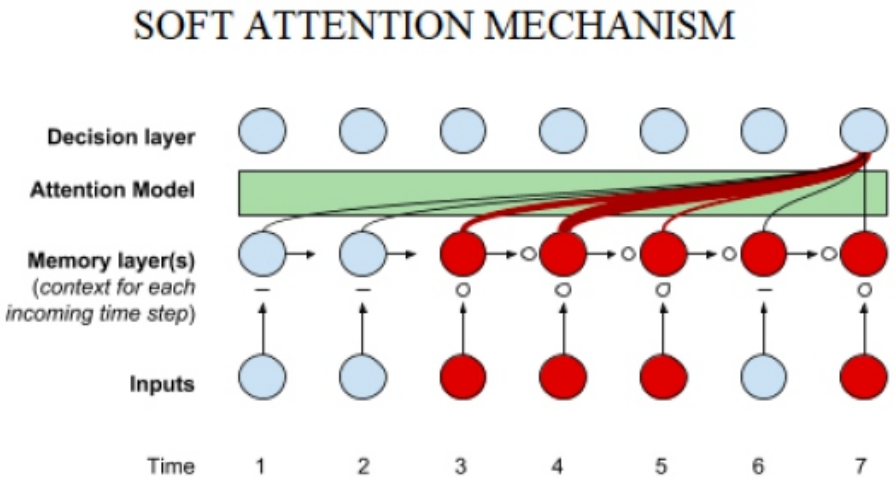


Figure 3: A diagrammatic representation of the soft attention mechanism

I. RELATED WORK

In view of increasing dependency on outdated methods for text analysis and information retrieval, a lot of research has been undertaken to devise a more efficient method of text parsing.

Various works have shown the efficiency of LDA systems to topic model and to tag important words, including LDA ad-hoc information retrieval (Xing Wei , 2006) and sentiment analysis as discussed in (Xianghua, 2013). The latter in particular, discusses the cutting edge Latent Dirichlet Allocation mechanisms for sentiment analysis of user social sentiment by leveraging and mining chinese social reviews. This therefore, also sets precedence in terms of LDA modelling for reviews.

In (Xing Wei, 2006), the authors discuss the effective information retrieval systems that are ad-hoc specialized and very narrow and concentrated in their applications. It proves that in ad-hoc conditions, an LDA is able to return a 95% confidence based on the wilcoxon test.

The earliest reference to MemN2N models was made in (Sukhbataar, 2015) which introduced a novel mechanism of end to end memory nets which over multiple hops easily outperformed other neural network models such as LSTM, RNN and CNNs. Furthermore, we find that end to end memory networks suggested in this paper are more suitable for multiple simultaneous computational hops. Due to its apparent efficiency in dealing with heavy duty data and large data sets, this mechanism is chosen over RNNs and LSTMs.

In (Huang, 2016), the hashtag recommendation system based on end to end memory, a model similar to recommendation system for restaurants is suggested. Similar to the hashtag recommendation system that prescribes a novel approach to tag and create relations between topics (bag of words), we want the restaurant recommender system to have a low recall and high efficiency.

(Xu Chen, 2018) defines an alternative memory mechanism for sequential recommendation, we draw inspiration from the novel approach in finding that though user's previous preferences and behavior records are not all equally important, in the sense that some behavioral aspects are much more prevalent and useful for future predictions as compared to others. A memory mechanism is able to overcome this. Despite the fact that the paper defines its mechanism based on a memory augmented neural network, it can be found that the latent memory matrix storage and manipulation similar to that of the end to end system. According to the paper, memory storage mechanism has again been recorded to be consistently more efficient as compared to RNNs and markov chains.

(Zhang, 2016) paper on phrase-level textual sentiment analysis across multiple categories or LRPPM, is helpful in breaking down the reviews into phrases, each with an individual context and finding correlation between the words in the individual lines.

(Chen Cheng, 2013) links the LRPPM model in the previous paper by discussing sequential correlation in his paper on successive points-of-interest recommender systems. These recommender systems offer higher accuracy and reliability as compared to other systems.

II. PROBLEM FORMULATION

This paper aims to develop an optimal recommendation algorithm which can accurately identify the preferences of the user based on historical data, user reviews, and the personal information obtained from the user. The aim is to build such a recommendation system that uses both content based and collaborative filtering methods to reach an optimal result. In this work, we aim to utilize the end-to-end memory network setup to parse the input reviews and to successfully identify and tag the key words that will be useful in predicting user behavior. Using state of the art NLP techniques such as attention mechanism, LDA topic modeling and bag-of-words implementation, this paper aims to make significant improvements in the performance of text based recommendation systems. An example of end to end memory system is shown below in figure(4) to demonstrate the use of temporal data and soft attention.

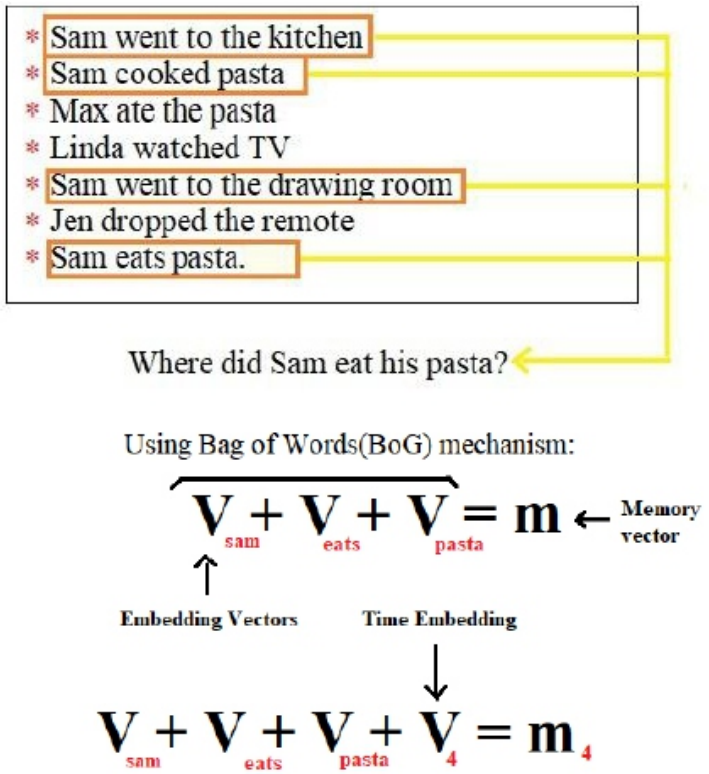


Figure 4: Working of a MemN2N system with time embeddings

As shown in the diagram above, the key difference in MemN2N architecture is the addition of memory and time embeddings separately while externalizing the memory.

III. WORKING MODEL

(a) Getting user's personal information from the application.

(b) Extracting User-item interaction matrix for user history.

(c) Reading the generated restaurant reviews for the chosen restaurant.

1) Cleaning extracted review words:

Prior to proceeding with text based analysis and modeling, there often is a need for cleaning and parsing the text. This is owing to the fact that almost all the text is created and stored in human-readable form, and it is challenging for a computer to process that text accurately. Most of the cleaning and parsing of text involves increasing the regularity and adding structure to the text. This involves: 1. Removing stop words 2. Fixing typing errors 3. Tagging some words as important, such as name, title, and etc 4. Lemmatization, grouping words with common roots

2) Latent Dirichlet Allocation (Topic tagging)

Every element or object is treated as a mixture of the extracted topics in a certain way. With respect to the text classification capabilities, the topic probabilities provide an almost accurate representation of the document. After LDA is completed, the topics of the review are all individually tagged.

3) TF-IDF bag of words:

TF-IDF, or term frequency–inverse document frequency, is a numerical statistic that is intended to reflect how important a word is to a document in a collection of words, or a sentence. It is often used as a weighting factor in searches of information retrieval, text mining, and user modeling. The tf–idf value increases proportionally to the number of times a word appears in the document.

4) Implementation of attention mechanisms:

While implementing attention mechanism, we find an unfortunate side-effect of using attentions in computational models. To successfully use the attention mechanism, we need to calculate an attention value for each combination of input and output word. Take for instance, a 100-word input sequence and generate a 100-word output sequence, that would be 10000 attention values. That doesn't sound too bad for the smaller denomination of word sequences, but if you do character-level computations and deal with sequences consisting of more than a hundred tokens the above attention mechanisms can become prohibitively expensive. Actually, that's quite counterproductive. Human attention is something that's supposed to save computational resources. By focusing on one thing, we are able to neglect many other things. But that does not seem to be possible with computational models. We're essentially looking at everything in detail before deciding what to focus on.

5) Word Embedding are created:

We use MemN2N as a language model. For instance, we parse any random review as the example: "The movie was great, it couldn't have been better. The first half was better than the second." Instead of 1 sentence per memory entry, we store only one word per entry as shown in figure(5):

WORD EMBEDDINGS

Memory slot	Word
1	The
2	movie
3	was
4	great
5	it
6	could
7	not
8	....

Fig 5: Word embedding

Algorithm for parsing reviews to meaningful information:

I. READ_TEXT

II. USE PRE-TRAINED LIBRARY MODULES TO IGNORE INCORRECT WORDS

III. REMOVE STOP WORDS

IV. CREATE WORD EMBEDDINGS, so now we have memory vector and embedding vector.

V. FIND TOPICS FROM EMBEDDING VECTOR

VI. if(TOPIC_ELEMENTS = Restaurant_tags) then add TOPIC_ELEMENTS to User-item Interaction matrix.

VII. END

Algorithm for collaborative recommendation implementation:

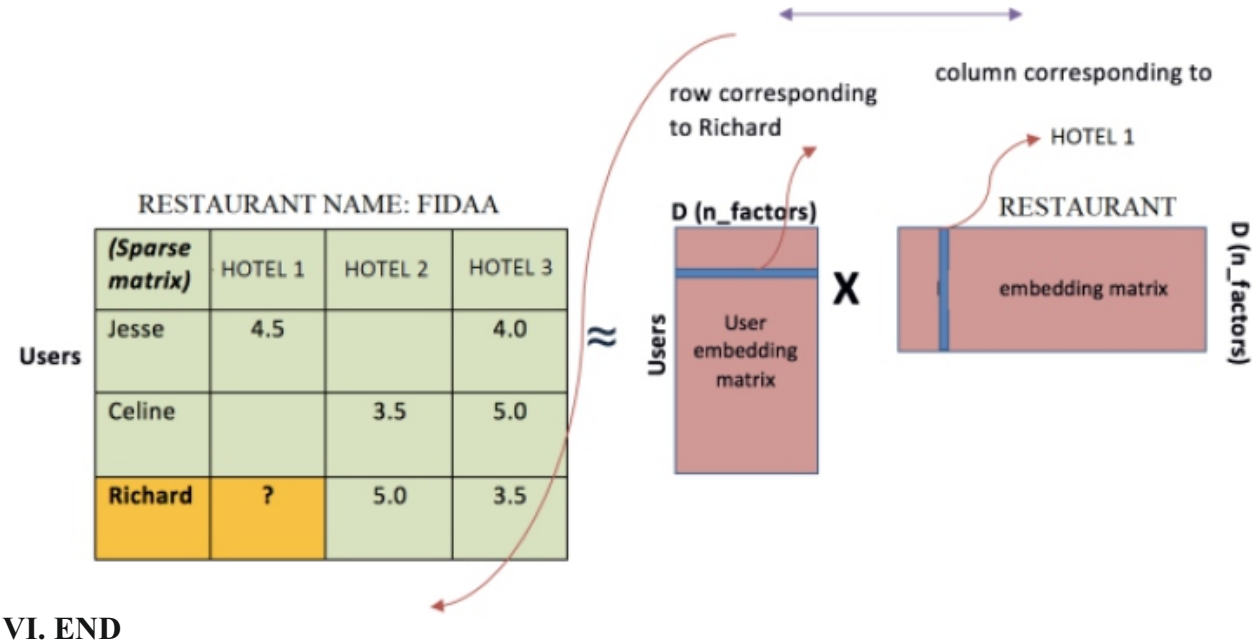
I. READ HISTORY DATA

II. LOAD DATASET CLASS

III. IMPLEMENT MATRIX FACTORIZATION, for eg. non-negative matrix factorization (NMF)

IV. CALCULATE VALID Root Mean Square Error (RMSE) values

V. RETURN SUGGESTION WITH THE LOWEST RMSE value.



VI. END

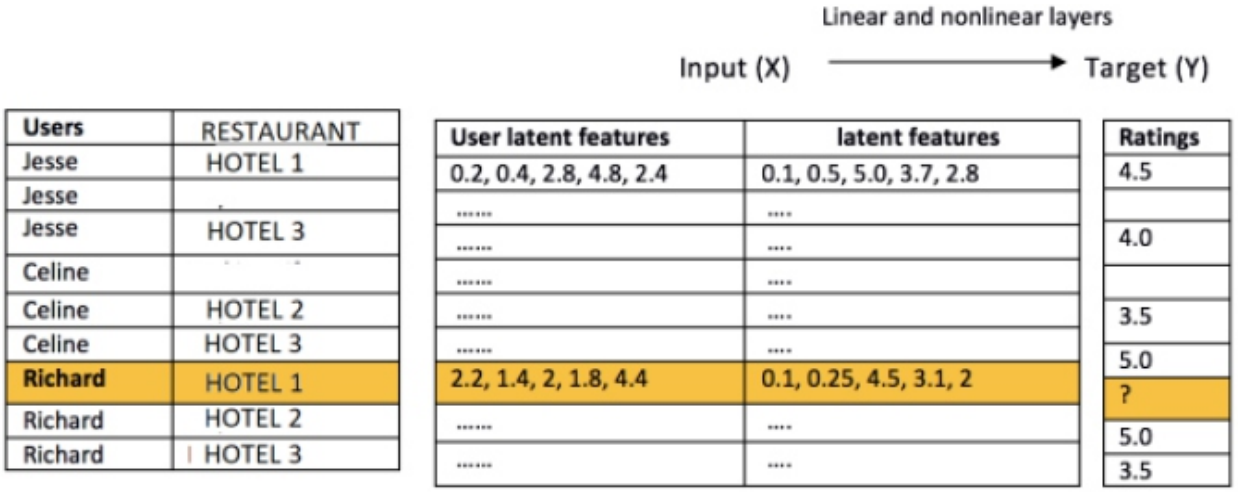


Figure 6: Figure depicting recommendation system

IV. COMMON MISTAKES

- Inaccurate model architecture.
- Inefficient train-test splits
- Not eliminating stop words
- Lack of lemmatization
- Implementing attention mechanism without rein-forcement learning approach, whereby increasing computational burden
- Overfitting the model on the database
- Tokenization and node optimization.

V. RESULT AND DISCUSSION

The results showed an interesting trend:

1) The best MemN2N models are reasonably close to the supervised models, although the supervised models are still superior.
2) All variants of our proposed model comfortably beat the weakly supervised baseline methods.
3) Joint training on all tasks helps.
4) Increased computational hops gives improved performance.

The recommendation system returned a validation accuracy of 95% in our implementation. The MemN2N model outperformed LSTM, RNNs and CNNs in our attempt.

Given below is the MSE of the implementation Figure (7).

Table : Performance Metric, as we can see increasing hops increases performance of the system. (10K training examples).

Model	Hidden	No. of Hop	Mem Size	Validation	Test Perf.	Mean Error	Failed Task (Error>5%)
RNN	300	-	-	133	129	26%	15
LSTM	100	-	-	120	115	36%	18
CNN	100	-	-	120	115	39%	20
MemN2N	150	2	100	128	121	6%	4
MemN2N	150	4	100	127	120	4.5%	3
MemN2N	150	6	75	122	114	4%	2

```
('Coefficients: \n', array([[938.23786125]]))
Mean squared error: 2548.07
Variance score: 0.47
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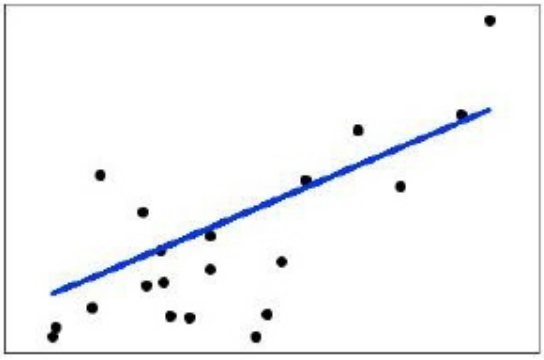

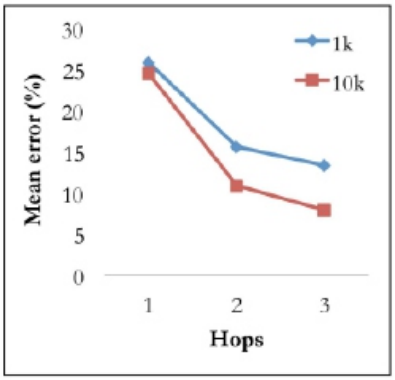

Figure8. MSE, Variance and 1K vs 10K training data comparison

VI. CONCLUSION AND SCOPE

In this work we showed that a neural network with an explicit memory and a recurrent attention mechanism for reading the memory can be used in recommendation tasks. It can be successfully trained to perform tasks in the NLP domain such as language modeling. Our model outperforms RNNs and LSTMs of comparable complexity. On both tasks we can see that increasing the number of memory hops improves performance. Using MemN2N reduced the need for training supervision and reduces memory load.

Compared to the Memory Network implementation of [9] there is no overall supervision required, because of this our model can be used in a plethora of use cases. Our model approaches the same performance of that model, and is significantly better than other systems with comparable supervision measures. On language modeling tasks, our model outperforms tuned RNNs and LSTMs of comparable complexity by a small margin.

In the future,

- more work needs to be done in particular to focus on making highly specialized specific recommendation systems such as this one.
- Work must be done to further reduce the memory burden.
- There is scope for addition of sentiment analysis in this system to further gauge the user sentiment.
- Currently the system only accepts reviews that follow a stringent grammar, with additional training, the system can be trained to handle human errors.

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Dual-Band Parasitic Microstrip Patch Antenna for Wireless Applications

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ABSTRACT

The paper presents a novel dual-band patch working at GSM band and S-band. The patch encompasses a rectangular radiator coupled with a parasitic patch in the coplanar region and a split ring resonator in the ground region. The patch is analyzed numerically and is synthesized using the HFSS simulator. Finally, the performance characteristics of the model are measured and are compared with numerical and simulated results. The patch gives two different bands at 950MHz and 2.3GHz and gives -10dB impedance bandwidth in the lower band from 950MHz -1GHz and higher band from 2.275GHz – 2.325GHz. The patch also accomplishes a gain of 4.74dBi in the effective band 1 and 4.02 dBi in the operating band 2.

Keywords: Dual Band, Energy harvesting, microstrip patch, rectenna, rectifier.

I. INTRODUCTION

Microstrip patches are mostly extensively used in wireless devices due to its less weight, ease of fabrication and better design optimization solutions [1]-[2]. It ranges from linear polarized [3] to circular polarized [4] patches, narrowband to ultra-wideband patches. This patch plays a crucial role in radar systems, satellite communications, military, and airborne communications and remote sensing applications. In general, the patches are fed by different techniques including coaxial fed, aperture coupling [5], microstrip line feed [6], the inset fed, proximity coupling [7], L feed [8] each having different advantages and its limitations. Recently graphene are also used to enhance antenna capabilities [9]. Dual-band patches are much more popular due to their ability to generate a strong signal in two bands which are much required in mobile communications systems. These patches have very sharp dual bands targeting only operating frequencies in the desired applications and also these bands are separated significantly from each other to avoid co-channel interference. These properties make dual-band patches are a stable and easy way to connect with other devices. Most of the paper discussed above lacks numerical analysis of the model and hence there is a need for systematic analysis of the patch model at each stage.

In the proposed work the most widely used rectangular patch is taken and is analyzed step by step through numerical equations to interpret the performance characteristics of the patch. It is then coupled with parasitic patch to induce additional band for wide applications including satellite communications.

Further, the work is extended to introduce SRR in the ground surface to enhance the patch performance characteristics. The proposed model is designed to operate at two different operating bands in GSM and S-band standards with sufficient gain characteristics suitable for various applications.

II. PATCH DESIGN PRINCIPLES

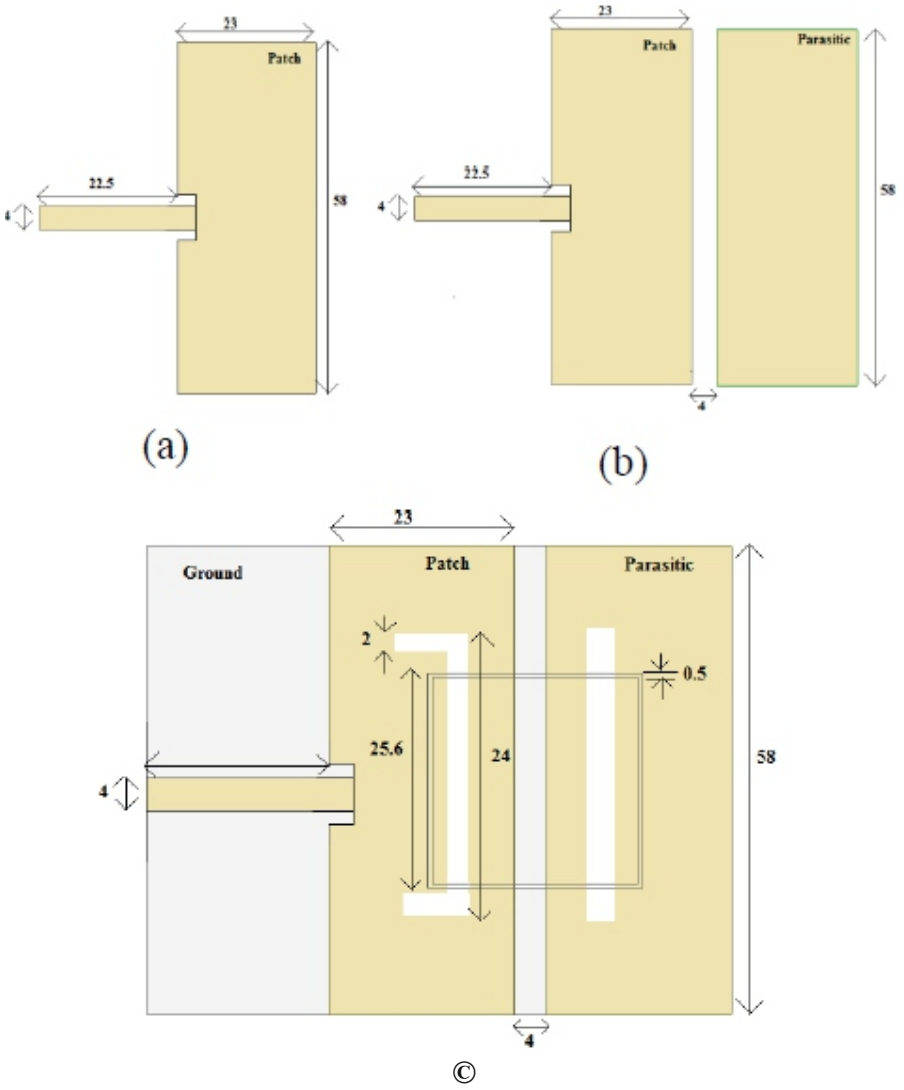

Fig. 1. (a) Rectangular patch patch (b) Rectangular patch patch with a parasitic patch (c) Proposed patch patch with SRR

The patch comprises of three stages. Initially, a simple rectangular patch as exposed in Fig. 1(a) is designed and its performance metrics are analyzed using HFSS. The second stage involves the introduction of a parasitic patch as exposed in Fig. 1(b) with a rectangular patch and its effects over the rectangular patch is studied. Finally, a slip ring resonator (SRR) is etched on the ground region as exposed in Fig. 1(c) is designed and the overall performance metric is studied. All the three patch models are considered on low loss substrate with a permittivity of 2.65 and a loss tangent of 0.0015 with a

thickness of 1.5mm. The entire model is designed on a single-layer substrate to make the patch less complex and feasible to integrate with other RF components. The patch is fed by an inset fed (50ohm) technique to make more control over patch impedance matching.

III. NUMERICALANALYSIS

The RLC circuit for a rectangular patch can be realized with RLC components terminated with input impedance Zp as depicted in Fig. 2.

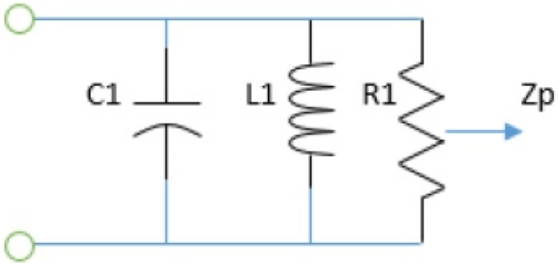

Fig. 2. RLC Circuit of Rectangular patch

The Corresponding RLC values of the radiator can be derived from equations specified below

$$C_1 = \frac{LW\varepsilon_0\varepsilon_e}{2H} COS^2\left(\frac{\pi X_0}{L}\right) \quad (1)$$

$$R_1 = \frac{Q}{\omega_r^2 C_1} \quad (2)$$

$$L_1 = \frac{1}{C_1\omega_r^2} \quad (3)$$

$$Q = \frac{C\sqrt{\varepsilon_e}}{4fH}$$

Where L, W, H are the Patch length, width, thickness, and X0- feed point location. The permittivity of the medium is taken as εr. The RLC model of parasitic patch coupled with the rectangular radiator is depicted in Fig. 3. The RLC components for the parasitic element is derived as same as rectangular radiator RLC components using equations (1)-(3). The RLC circuit is terminated with an input impedance of Z_{pp}.

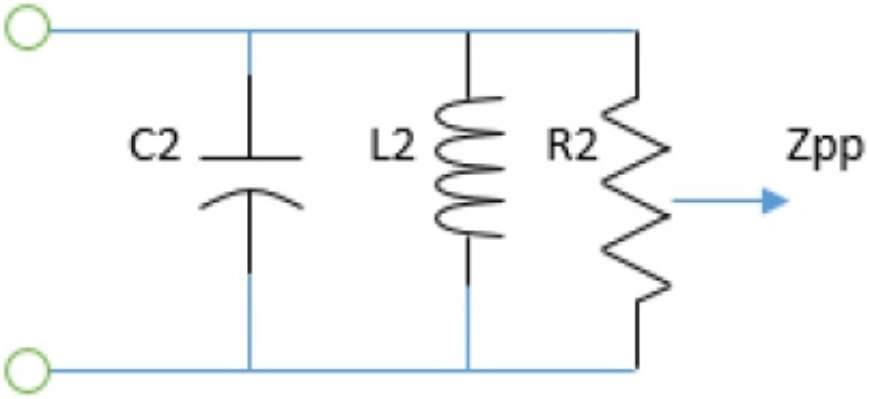

Fig. 3. RLC circuit model for parasitic patch

Between the patch element and the parasitic element, there exists a gap region, which adds a capacitive effect over the patch circuit. The RLC model for the overall capacitance value resulted from the gap region is depicted in Fig. 4 and is derived using equation (4)-(5) given below

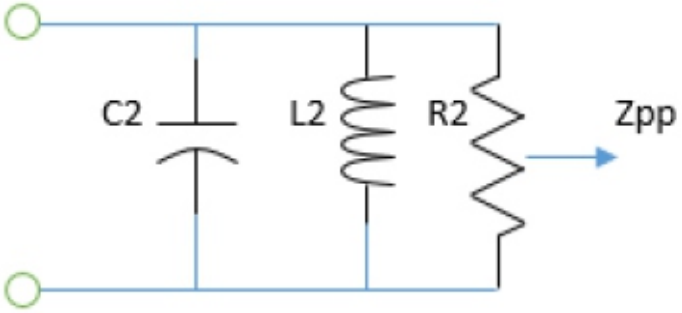

Fig. 4. RLC circuit model for Gap Capacitance

$$C_g = 0.5.H.Q_1 exp\left(-1.86\left(\frac{G}{H}\right)\right)\left[1 + 4.09\left\{1 - \right.\right.$$
$$\left.\left. exp0.75HW \right.\right. \quad (4)$$

$$C_{p1} = C_L\left(\frac{Q_2+Q_3}{Q_2+Q_1}\right) \quad (5)$$

Where

$$Q_1 = 0.04598\left\{0.03 + \left(\frac{W}{H}\right)^{Q_4}\right\}(0.272 + \varepsilon_r 0.07)$$

$$Q_2 = 0.107\left[\frac{W}{H} + 9\right]\left(\frac{G}{H}\right)^{3.23} + 2.09\left(\frac{G}{H}\right)^{1.05} + \left[\frac{1.5+0..3\left(\frac{W}{H}\right)}{1+0..6\left(\frac{W}{H}\right)}\right]$$

$$Q_3 = exp(-0.5978) - 0.55$$

$$Q_4 = 1.23$$

Finally, the RLC circuit model for the feed is depicted in Fig. 5. The line is terminated with impedance ZL. The Land Components of the feed line is derived from equation (6)-(7)

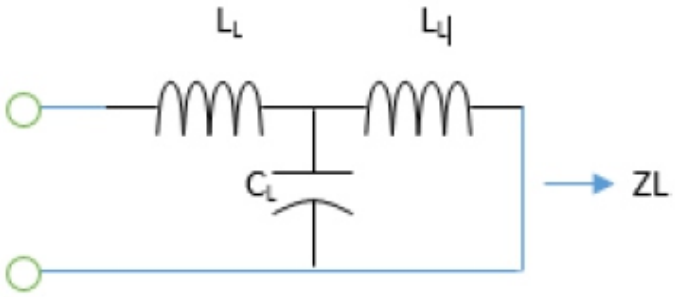

Fig. 5. RLC circuit model for Feedline

$$C_L = C_H \frac{\sqrt{\varepsilon_{eff}}}{Z_0 c}$$

$$C_H = 0.412 \left[\frac{(\varepsilon_e+0.3)\left(\frac{W}{H}+0.264\right)}{(\varepsilon_e-0.258)\left(\frac{W}{H}+0.8\right)}\right]$$

$$L_L = 100.H\left(4\sqrt{W_s/H} - 4.21\right)nH \qquad (6)$$

$$C_L = W_S\{(9.5\varepsilon_r + 1.25)\, W_s/H + 5.2\varepsilon_r + 7.0\}pF \qquad (7)$$

Where CL is the Feedline capacitance and LL is the feed line inductance. The overall RLC model for the proposed patch is depicted in Fig. 6.

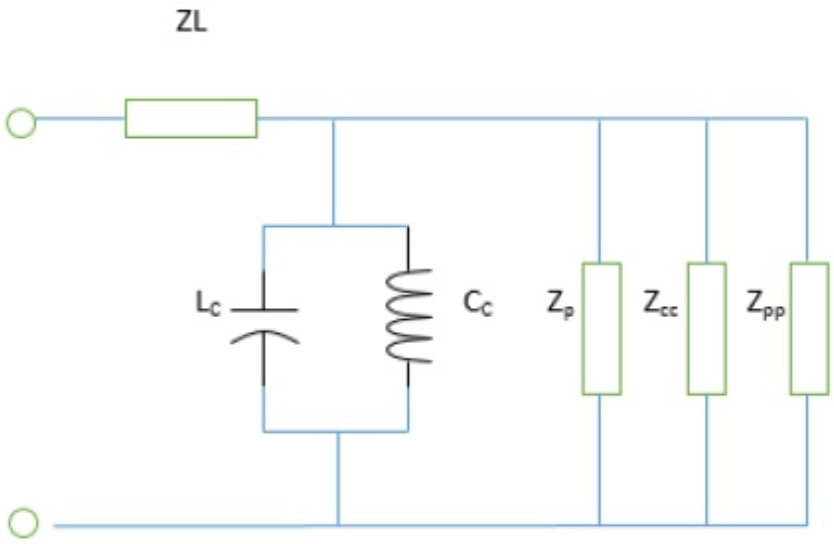

Fig. 6. RLC circuit of proposed model

In general, the resonant frequency is derived from equation (8)

$$f = C/2L_{es}\sqrt{\varepsilon_{re}} \qquad (8)$$

Where L_{es} is the effective realized length and ε_{re} is the effective realized permittivity of the substrate or the medium whose value are given below.

$$\varepsilon_{re} = 1/2\left[(\varepsilon_r + 1) + (\varepsilon_r - 1)(1 - 12.H/W_s)^{-1/2}\right]$$

$$L_{es} = L_s + \Delta L_S$$

$$\Delta L_S = H.0.412 \left[\frac{(\varepsilon_{re}+0.3)\left(\frac{W_S}{H}+0.264\right)}{(\varepsilon_{re}-0.258)\left(\frac{W_S}{H}+0.8\right)}\right]$$

The Characteristic impedance Z_L and the input impedance Z_{in} of the patch is given in equation (9)-(10) given below.

$$Z_L = j\omega L_L + \frac{1}{j\omega C_L + \frac{1}{j\omega L_L}} \quad (9)$$

$$Z_{in} = Z_L + \frac{1}{\frac{1}{j\omega C_L + \frac{1}{j\omega L_L} + \frac{1}{zp} + \frac{1}{zpp} + \frac{1}{zcc}}} \quad (10)$$

Based on the above equations, the performance characteristic metric such as reflection coefficient, VSWR and return loss are deduced using the equations given below.

$$\Gamma = \frac{Z - Z_{in}}{Z + Z_{in}}$$

$$VSWR = \frac{1 + \Gamma}{1 - \Gamma}$$

$$R_L = 20\ log\ |r|$$

IV. PARAMETRIC ANALYSIS OF THE PROPOSED PATCH

Analysis of antenna design parametric dimensions is carried to determine the result of design restrictions over patch performance metrics. Fig. 7 depicts the effect of substrate thickness over the patch impedance characters. It is observed that with a rise in antenna substrate thickness moves the operating band (both lower and the upper band) towards higher resonating regions.

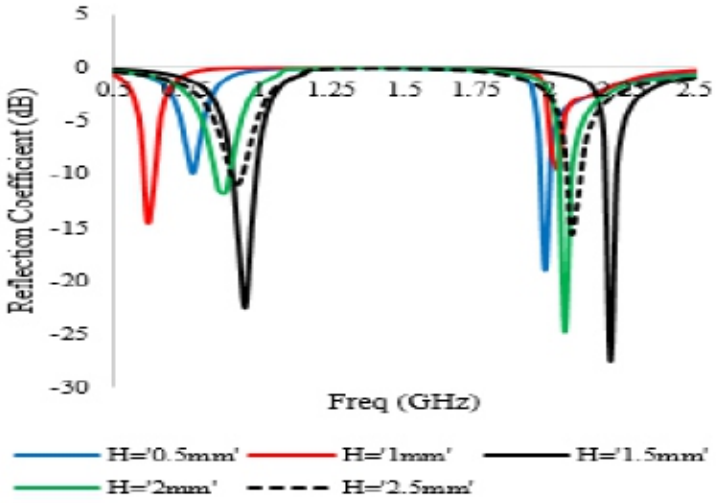

Fig. 7. Effect of substrate thickness (H) on reflection coefficient (dB)

Fig. 8 shows the effect of feed line width (Ws) over the patch impedance bandwidth. It is observed that with a rise in patch substrate thickness moves the operating band (both lower and the upper band) towards lower resonating regions. This is due to the effect of capacitance CL over patch frequency bands as both are directly proportional to each other.

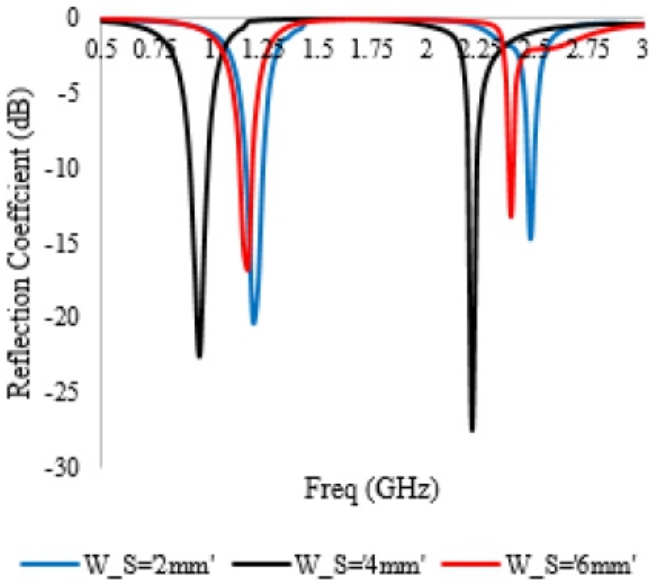

Fig. 8. Effect of feed line width (Ws) over the reflection coefficient (dB)

Fig. 9 shows the result of feed length (Ls) over the patch reflection coefficient. It is observed that with an increase in patch substrate thickness moves the operating band (both lower and the upper band) towards higher resonating regions. This is due to the effect of Ls over patch frequency bands as both are inversely proportional to each other.

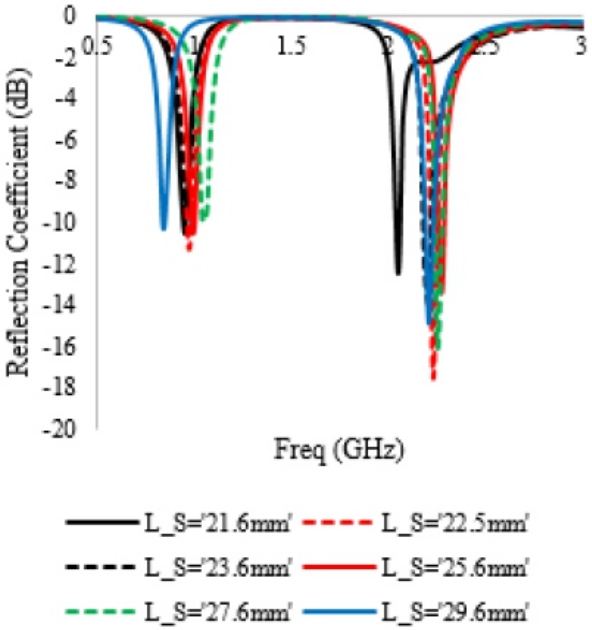

Fig. 9. Effect of feed line length (Ls) over the reflection coefficient (dB)

Fig. 10 shows the effect of the Gap region (G) over the reflection coefficient (dB). It is observed that change in gap regions swings the patch band (both upper and lower band) between two ends of the operating frequency regions.

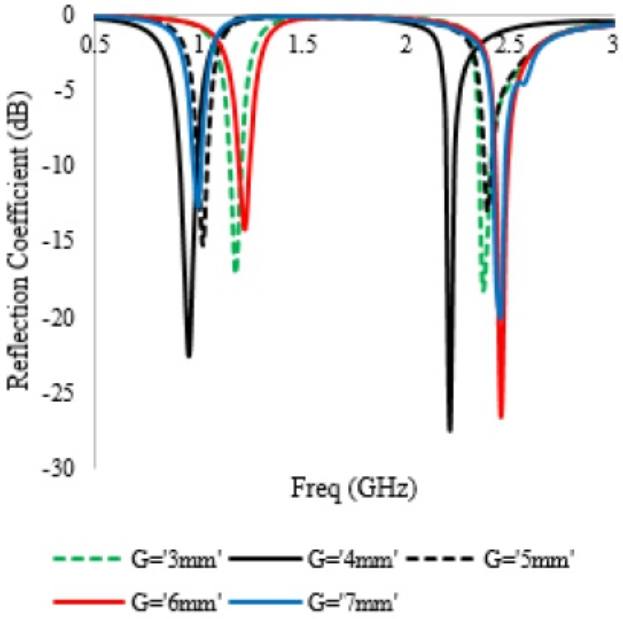

Fig. 10. Effect of Gap region (G) over the reflection coefficient (dB)

V. RESULTS AND DISCUSSIONS

Base on the above equations discussed in numerical analysis and parametric analysis, the RLC values of the patch design are given in Table I.

Table I. Patch design dimensions

Parameter	Specifications
Substrate Height (H)	1.5mm
Permittivity (εr)	2.64
SLoss Tangent (tanδ)	0.0015
Patch width and Parasitic width (W)	23mm
Patch Length and Parasitic Length (L)	58mm
Feedline Length (Ws)	22.5mm
Feedline Width (Ws)	4mm
Gap region (G)	4mm
Notch_width (WN)	2.74
Notch_length(LN)	7.24
SRR thickness (ST)	0.5mm

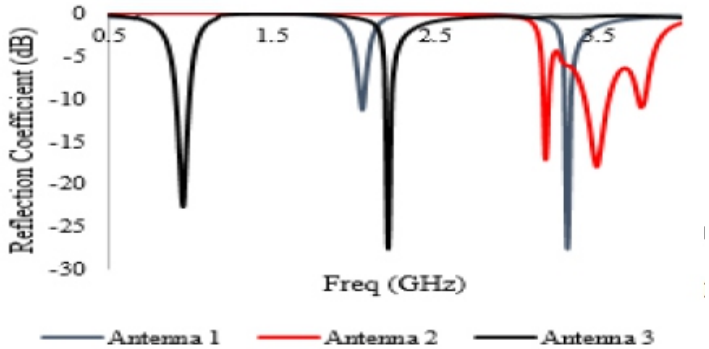

Fig. 11. Comparison of the proposed patch with other patch models.

The proposed patch model is designed using HFSS and is simulated. The resultant output is compared with both numerical and experimental results. Fig. 11 shows the impedance curve for a rectangular radiator patch model with a parasitic model without SRR and proposed a model with SRR. It is witnessed that the patch functions at two different bands at 950MHz and 2.3GHz. The model gives -10dB impedance bandwidth in the lower band from 950MHz -1GHz and a higher band from 2.275GHz – 2.325GHz.

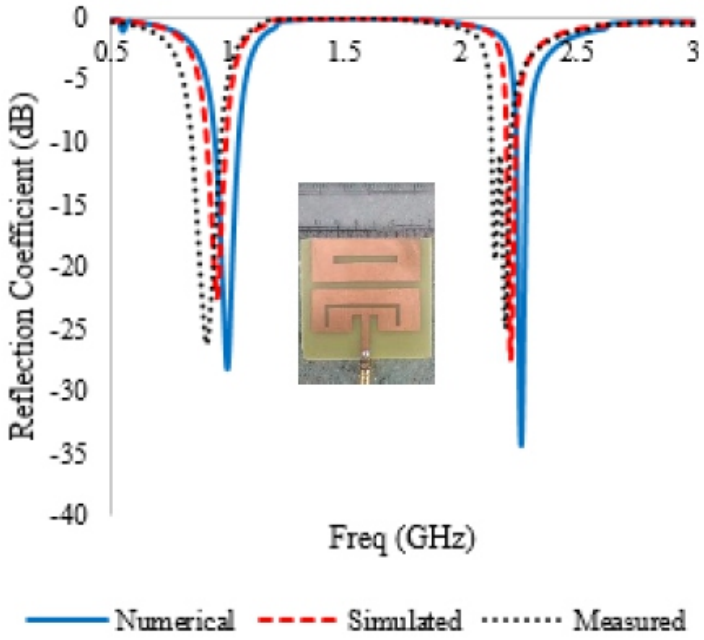

Fig. 12. Impedance characteristics of the patch.

Fig. 12 shows the comparison of -10dB impedance bandwidth curve observed from simulated, numerical and experimental results. It is inferred that the impedance bandwidth curve obtained from simulated, numerical and experimental results is closely matched with each other.

The radiation characteristic of the patch is simulated and are validated. The resultant radiation pattern is given below.

Fig. 13 shows the radiation shape for the E and H plane corresponding to 950 MHZ (Band 1). The plot displays the relationship of both simulated and measured pattern. It is inferred that the patch gives an omnidirectional pattern for the E plane and doughnut shape pattern for the H plane in working band 1 with a gain of 4.74dBi.

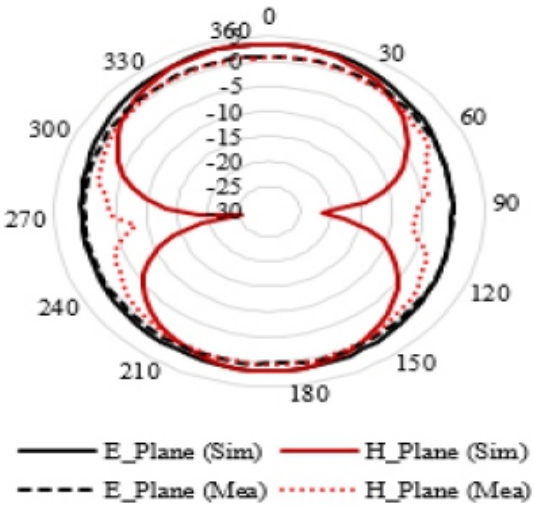

Fig. 13. Radiation pattern for band 1.

Fig. 14 shows the radiation shape for the E and H plane corresponding to 2.3 GHz (Band 2). The plot displays the relationship of both simulated and measured pattern. It is inferred that the patch gives an omnidirectional pattern for E plane and doughnut shape pattern for the H plane in the operating band 2 similar to that of band 1 with a peak gain of 4.02dBi.

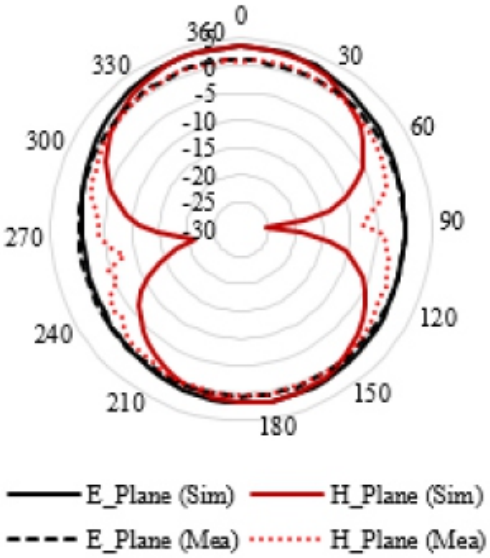

Fig. 14. Radiation pattern for band 2.

VI. CONCLUSION

The paper presents a novel dual-band patch loaded with SRR resonators. The patch is excited by 50-ohm inset fed and is designed on the single-layer substrate. The patch resonates at two different bands at 950MHz and 2.3GHz and gives -10dB impedance bandwidth in the lower band from 950MHz -1GHz and higher band from 2.275GHz – 2.325GHz. The patch also achieves a peak gain of 4.74dBi in the operating band 1 and 4.02 dBi in the operating band 2. The proposed design can be used for modern satellite communication for both uplink and downlink data transfer processes.

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Water Quality Monitoring System for Aquaponics and Fishpond Using Wireless Sensor Network

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ABSTRACT

The higher the human population, the higher the demand for food supply from the agriculture sector. However, healthy and environment-friendly plant-based food production is very time-consuming. Water quality checking by the human resource is no longer efficient in the presence of technology today. Thus, a water quality monitoring system for aquaponics and fishpond is proposed in this study adapting the use of Wireless Sensor Network (WSN), Message Queuing Telemetry Transport (MQTT) protocol, and Wi-Fi signal. The completed system was successfully tested and implemented at the Malaysian Institute of Sustainable Agriculture (MISA). The devices send measurements to a base station which hosted a web server which can be viewed both locally and via the Internet. Results show the system is practical in use as it is both stable and reliable with 5 seconds maximum measurement refresh rate on its dashboard. Thus, reduces human dependency for monitoring the water quality of both the aquaponics and fishpond. Human resource can then be allocated to more crucial roles. Room for improvement includes complete use of solar renewable energy, adding Wi-Fi extender for large scale implementation, and equipping the Raspberry Pi with a cooling fan. This is the step forward to modernising agriculture.

Keywords: Aquaponics, fishpond, monitoring system, MQTT, water quality, WSN.

I. INTRODUCTION

As the human population grows today, so as the demand for food supply from the agricultural sector. Plant-based foods take more time to produce compared to meat-based [1]. In addition, society today is concern on healthy food which includes vegetables and the environment from plantation as various information is at their fingertip [2]. This arises from the awareness of the danger of eating food which is sprayed with pesticides. Furthermore, the pesticides used in plantation causes soil pollution which also pollutes any nearby water source such as lakes and rivers [3]. Aquaponics is an efficient food production mechanism which combines both plant and fish farming together in a harmony environment. Technology today had advanced rapidly beyond our imagination ten years ago. However, the local agricultural sector is still far behind compared to other industrial sectors in adapting technology in production [4]. Since agricultural activities involve many routines, adapting remote monitoring had potentials in increasing efficiency in food production [5]. Currently, human resource is inefficiently allocated for water quality checking routine instead of focusing on a task which is incapable to be

handled by computers. Thus, a water quality monitoring system for aquaponics and fishpond using Wireless Sensor Network (WSN) is proposed in this study to reduce water quality testing routine by MISA's staff besides increasing their efficiency in task assignments.

Design of wireless connectivity solution was based on several past works. Works by [6], [7], and [8] uses Zigbee wireless technology in their solution for smart farm monitoring system using IoT, implementation of a connected farm for smart farm, and IoT based smart irrigation monitoring and controlling system respectively. Zigbee is quite costly and a little more complex in term of usage compared to Wi-Fi. A work by [9] uses Wi-Fi signal as data transmission platform in adapting WSN for modern agriculture. It has the advantage of low-cost and easy implementation. A work by [10] uses Message Queuing Telemetry Transport (MQTT) protocol for smart agriculture has the advantage of rapid data transmission. A work by [11] adapted the use of WSN for smart farming has the advantage of efficiency in data collection for various sites. Based on the several designs presented, application of WSN using MQTT via Wi-Fi was chosen as the best solution design for this study's application.

II. METHODOLOGY

This study focuses on hardware and software development which also includes experimentation on the system. Fig. 1 shows the flow of the study.

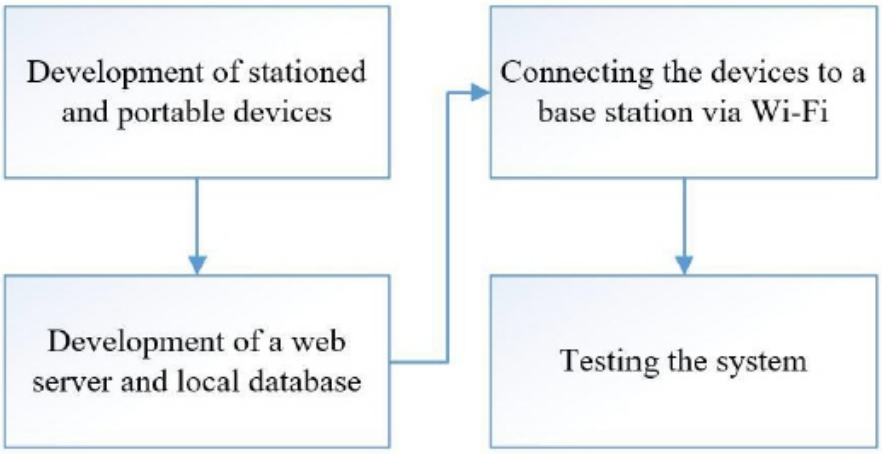

Fig. 1. The flow of the study.

A. Hardware Design

A Raspberry Pi 3 Model B+ microcomputer which comes with a built-in Wi-Fi module is placed in an office as a base station for data collecting and hosting the monitoring system's web server. It can also utilise a personal computer for basic office tasks. A 32GB microSD card is used for the Raspberry Pi as it is sufficient for an operating system and local data storage. A standard Raspberry Pi casing is used for protection of the microcomputer. Fig. 2 shows a stationed water quality measuring device is used for aquaponics.

Fig. 2. The stationed device for aquaponics.

While a portable water quality measuring device is used for a fishpond which is also known as iFloat as shown in Fig. 3 in testing. The three devices are connected via Wi-Fi to a portable 4G modem which supports virtual servers for port forwarding to allow remote access of the monitoring system. Placement of the Wi-Fi modem is also crucial to ensure all the devices are covered within its Wi-Fi signal range. Since the Raspberry Pi is hosting the webserver, the stationed and portable devices only have to send measurements to the Raspberry Pi via Wi-Fi. Thus, a WeMos D1 board is used for both devices as it is Arduino Uno compatible and has a Wi-Fi module together. In addition, the portable device uses a 12V 1.2Ah lead-acid battery for powering up and a small solar panel for recharging it in daylight. While the stationed device which includes an automation system for the aquaponics' Light-Emitting Diode (LED) and water pump uses a direct power supply.

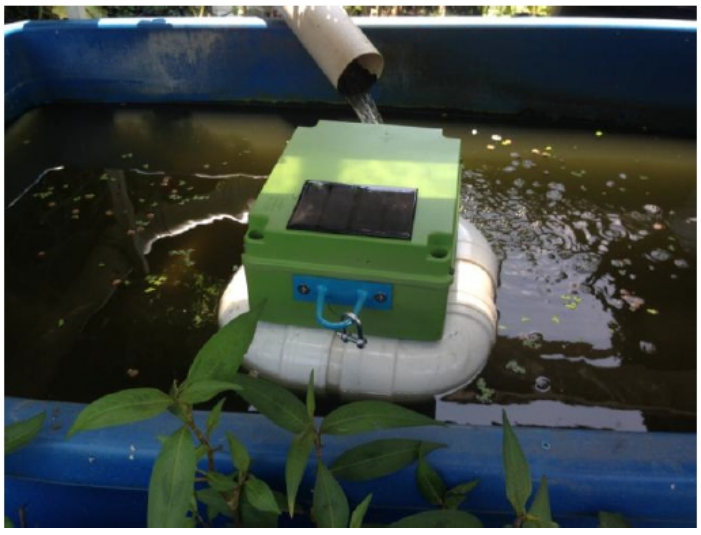

Fig. 3. The portable device in testing.

B. Software Design

Raspbian Buster operating system (OS) is used on the Raspberry Pi as it is the latest and official OS. Docker which is a container-based environment was set up on the OS. Portainer was installed and run on the Docker to give it a user-friendly interface. A time-series database (TSDB), InfluxDB was installed and run on the Docker to store measurements from both the stationed and portable devices locally in the Raspberry Pi's microSD card since it has a sufficient storage space. For data visualisation, Grafana web server was installed and run on the Docker which retrieves measurements stored in the database and displays it according to the user's configuration on the webserver. In term of wireless data transmission, Message Queuing Telemetry Transport (MQTT) publish-subscribe-based messaging protocol is used via the Wi-Fi connection between the Raspberry Pi, stationed, and portable devices. Furthermore, JavaScript Object Notation (JSON) format is used in the data transmission. The Raspberry Pi subscribes to a topic in which the stationed and portable devices publish its measurements via the respective WeMos's Wi-Fi module. A Python code script was made and run on the OS for subscribing and listening to the topic for any measurement publish by the stationed and portable devices. In addition, the Python script stores the received measurements in the database for visualisation. The flow of data is shown in Fig. 4. Aside from that, port-forwarding is made on the Wi-Fi modem to allow external connection to access via the Wi-Fi modem to the webserver. A free Dynamic Domain Name System (DDNS) service provider is used to link between the Raspberry Pi's dynamic public Internet Protocol (IP) address and the webserver's host port to allow remote user access.

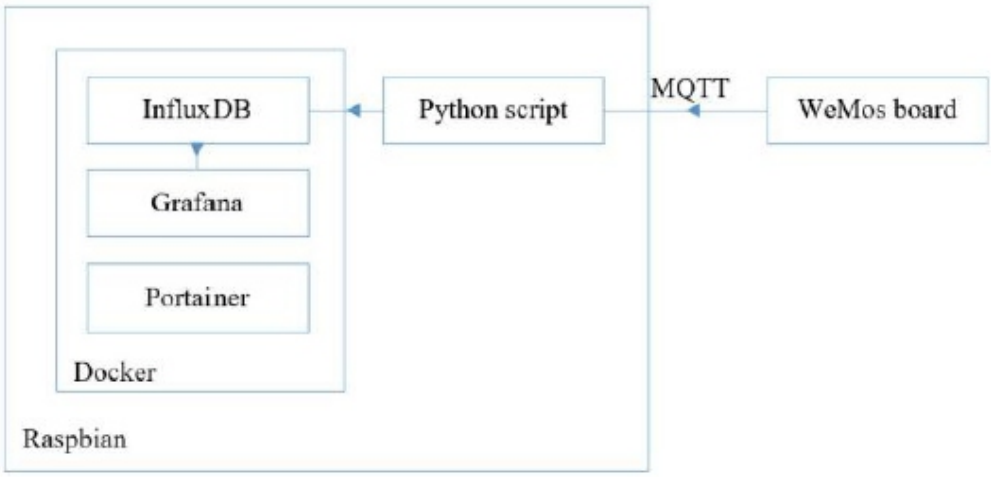

Fig. 4. The flow of data.

C. Experimentation

Tests were carried out on-site at the Malaysian Institute of Sustainable Agriculture (MISA), a foundation focuses on urban and organic farming. The Raspberry Pi was placed in the office, the stationed water quality measuring device was set up on aquaponics, and the portable water quality measuring device was placed in a fishpond. The portable Wi-Fi modem was placed at a central location between all the devices

as shown in Fig. 5 to ensure its Wi-Fi signal range is within range of all the devices. The system was run at a 24-hour basis to observe its reliability and performance.

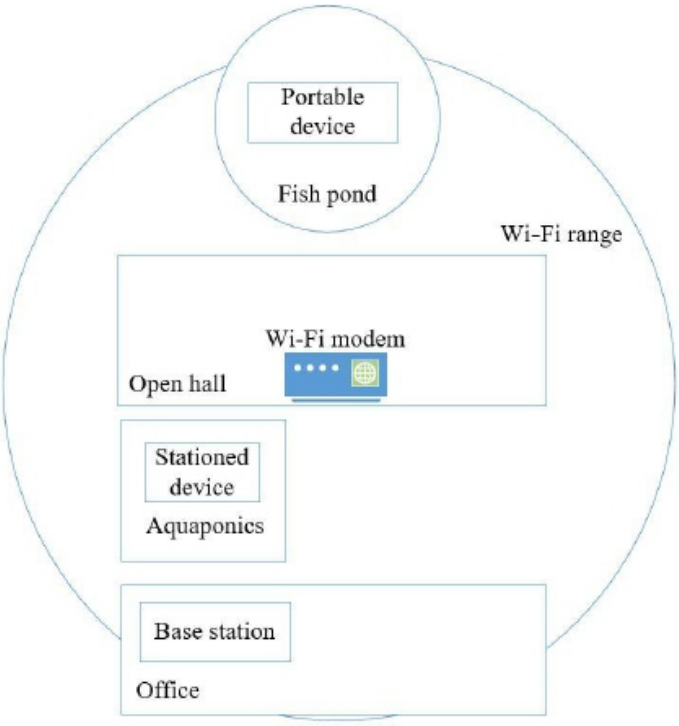

Fig. 5. Position of devices in MISA.

III. RESULTS

The stationed and portable water quality measuring devices successfully sent their measurement to the Raspberry Pi. The measurements are then successfully displayed on the hosted web server as shown in Fig. 6. The measurements include water pH level, water and ambient light level in Analogue-to-Digital Converter (ADC) value which ranges from 0 to 1023. In addition, the system also includes the Raspberry Pi's disk space usage, CPU temperature, and CPU usage level. This is to monitor the Raspberry Pi's health status as the base station of the system.

Fig. 6. Grafana dashboard for the stationed device before integrated with the portable device.

Table I shows the selected measurement period of the stationed device every 6 hours on the 22nd and 23rd of July 2019. The pH level is high around the 00:00 hour of 23/7/2019 due to the MISA's staff adding lime powder to reduce the acidity of the water. In the other hand, the water level is steadily decreasing throughout the period due to vaporisation. While ambient light level shows a very low level at midnights and very high level at middays.

Table- I: Selected measurement period of the system

Date	Time (24 hour)	pH	Water Level	Light
22/7/2019	00:00	2.5	147.2	119.8
	12:00	2.7	126.3	945.6
23/7/2019	00:00	13.7	111.7	120.9
	12:00	2.9	89.6	947.0

While Fig.7 shows the measurement of the portable device after integration into the dashboard. Furthermore, the system has successfully run for a week without having any data lost or technical problem on the webserver. Moreover, measurements are sent at an average one second per reading from each of the two water measurement devices. Thought the webserver's maximum refresh rate for new readings is 5 seconds which is acceptable for this study's application. The Raspberry Pi's still have a significant storage space upon running for a week and its average temperature measurement is still acceptable although sometimes it's quite high. In addition, the user can choose a time range of measurement to be displayed and suitable refresh rate of the dashboard. The webserver also can be accessed locally and via the Internet for user convenient. Thus, the webserver is stable and reliable for a continuous twenty-four seven monitoring system.

Fig. 7. Grafana dashboard for the portable device after integration.

IV. CONCLUSION

The wireless monitoring system is successfully developed with a base station, a stationed water quality monitoring system for an aquaponics and a portable water quality monitoring system for a fishpond. The monitoring system utilises the fast responding MQTT protocol to send data wirelessly to a Raspberry Pi as a base station for local storage and visualisation. Using open-source software, a web server is hosted locally on the Raspberry Pi and extends its accessibility via the Internet. The completed system was successfully tested and implemented at MISA's aquaponics and fishpond. Based on the experimental results, the system proofs to be stable and reliable for use at site. Thus, reducing MISA's staff routine task of checking the water quality of both the aquaponics and fishpond. Nonetheless, room for improvement is always open wide. A large battery and solar panel can be used to supply power to the stationed device instead of using the direct power supply in support for using renewable energy and cut electricity cost. For large scale implementation of the system which covers a wide area, several Wi-Fi extenders can be used to increase the range of the local Wi-Fi network signal. It is recommended to provide the Raspberry Pi with casing including a mini fan to cool it down as its temperature will rise upon an increase in user activity on the microcomputer. Application of technology in agricultural sector improves the efficiency of food production to support the growing population's food demand. This is a small step towards smart farming that is actively being promoted today and attract the young generation to get involved in developing it.

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